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POLLUTION SOURCE REDUCTION:

A TRAINING MANUAL

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INTRODUCTION

When I was a graduate student, an oft-expressed complaint was the curriculum's lack of "relevance" to the needs of soon-to-be practicing professionals. Now, as a public official, I hear similar complaints that students are not trained in areas critical to fulfilling our mission. If neither students nor faculty nor employers act, these complaints are all too likely to have a large degree of truth to them.

This volume represents an effort to bridge the "relevancy gap". It is a manual for the training of students, and to some extent faculty and agency people, in a new approach to environmental management. Rather than focusing on the control of toxic emission, this manual emphasizes the need to move upstream in the production process and reduce or eliminate the use of toxic substances and hazardous waste. Source reduction, as we call it, should be the primary means of protecting public health and safety. But all too often, academia, reinforced by professional societies, has paid lip service to process controls and focused on end-of-pipe solutions. No one has been training people in source reduction.

When the Department of Environmental Management (DEM) began its source reduction program in 1983, on-the-job training was the only means for developing expertise. In 1986, we began a project that would provide technical assistance on source reduction to the jewelry plating industry in southeastern Massachusetts and found few professionals capable of meeting our needs. With the support of the Center for Energy and Environmental Studies at Boston University, we decided to train our own professionals. The result was a multi-session program held during winter 1987 for students, faculty, and selected guests that would enable students to provide professional assistance to the companies participating in the source reduction project. The sessions were led by guest speakers in addition to Boston University faculty who offered their time and experience to train a new generation of environmental professionals committed to source reduction principles.

Numerous inquiries about the sessions suggested the need for a manual based on the training program. Included here are slightly revised versions of the major talks given during the sessions. While much of the sessions are applicable nationally, some of the material is specific to Massachusetts.

The first session was led by Lee Dane from DEM, who gives an overview of the Department's source reduction efforts and the Southeast Jewelry Platers Project in particular. Her introduction is followed by T. R. Lakshmanan's discussion of the economic benefits of source reduction. Lakshmanan, of Boston University, focuses on the electroplating industry in general. Turning to southeastern Massachusetts, Brenda Reed from the Governor's Office of Economic Development and a former Mayor of Attleboro, describes the economic climate in that region and the potential benefits of a strong source reduction effort by local industries. Henry Henderson from Boston University gives a history of federal water pollution control law. He is followed by George Furst from the U.S. Environmental Protection Agency Region I office who gives a general discussion on hazardous waste regulations.

The next set of talks review specific EPA and state policies regarding water and hazardous waste enforcement. Gerald Potamis from EPA Region I reviews the water quality regulations. State enforcement policies at the Department of Environmental Quality Engineering are the subject of Tom Powers presentation. Also from DEQE, Doug Wallace explains the state recycling regulations for hazardous waste generators. The last set of talks consists discussions of wastewater treatment and source reduction by industry consultants. Bill Hebard introduces wastewater treatment techniques specific to electroplating waste streams. Good process management is the topic of Oscar Nietzel's talk. The last topic is maximizing source reduction in a manufacturing process, presented by Robert Capaccio.

The success of the training program itself was due primarily to the vision and hard work of Professor T. R. Lakshmanan of Boston University and Lee Dane and Charles Baxter of the Office of Safe Waste Management in DEM. The time and effort contributed by the guest speakers for preparing their talks and revising their written remarks is greatly appreciated. I would also like to thank the students who participated including Rita Aggarwall, Steven Angel, Mariza Cabral, Diane Greaney, Youxiang Sun, and Richard Zeroka. Beth Furst, an intern in the Office of Safe Waste Management, also participated. They were the reason for the program and those who went on to help in the jewelry platers project proved to be extraordinarily capable. Lee Dane and Rick Reibstein at DEM and T. R. Lakshmanan helped turn the talks into this manual.

We hope this is the start of programs across the nation that will train professionals to avoid the use of toxic substances and the generation of hazardous emissions. To that end, we encourage dissemination of this manual. For more information, please contact the Office of Safe Waste Management, Department of Environmental Management, 100 Cambridge Street, Boston, MA 02212 (617-727-3260),

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The Southeast Jewelry Platers Project
Technical Assistance for Source Reduction of Hazardous Waste

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The Department of Environmental Management (DEM) is charged with planning and facilitating the safe and efficient management of hazardous waste in the Commonwealth. DEM's Office of Safe Waste Management (OSWM) evaluates statewide needs for proper management, provides policy guidance to the executive office and Legislature, educates the public on hazardous waste issues, involves the public in facility siting efforts, and provides technical information and assistance to communities and generators of hazardous waste.

Since 1983, DEM has been involved in promoting the reduction of hazardous waste among the state's generators. Source reduction is defined as any activity undertaken by a generator within a process to reduce or eliminate hazardous wastes and emissions before they are generated. Source reduction activities include input substitution, process change and product reformulation.

When the program first began, staff efforts concentrated on identifying and weighing alternative policies that would promote source reduction. Concurrently, the Department believed that it was important to provide information to generators, environmentalists and the general public on regulations, waste management options and source reduction technologies.

Initially, information was disseminated both informally through responses to telephone inquiries, and formally through workshops, seminars and an annual conference on source reduction for Massachusetts generators. During this period, DEM also began to provide technical assistance to small quantity generators (SQGs) of hazardous waste (those who generate less than 1,000 kilograms of waste per month) and to communities interested in improved management of household hazardous waste. In addition, DEM grants were awarded to regional coalitions of planning agencies, environmentalists and industry for projects such as tec cal assistance to local industries regarding their hazardous ste

problems. Experience with these efforts suggested the feasibility of a technical assistance program specifically on source reduction.

Genesis of DEM's Source Reduction Technical Assistance Program

In its efforts to identify policies which would lead to a statewide approach to source reduction, DEM sponsored a survey of waste generation, management practices, and source reduction potential. While the study could not be completed, it suggested that a variety of source reduction efforts were underway and that there was significant potential for further reductions in waste generation. Subsequent analyses evaluated a variety of policy approaches followed in other states. A consistent finding was that source reduction was not necessarily amenable to regulatory action. Rather, a variety of positive incentives appeared to engender a maximum level of effort by generators in specific industries.

Based on this research and a decision to pursue a technical assistance program within DEM, staff examined waste streams, processes and industry segments important to Massachusetts to identify an appropriate pilot project to get the program off the ground. Criteria for determining a project focus included:

1.) Waste quantity and type of hazard by industry segment.

2.) Size and geographic distribution of industry

3.) Degree of expected cooperation from industry and appropriate trade associations.

4.) Likelihood of success in increasing compliance

5.) Availability of existing waste management resources in the industry.

6.) Opportunities for multiplier effects (people who attend workshops educating others).

7.) Availability of existing waste management resources in the industry. Using these criteria, electroplaters and other metal finishing industries were high on the list, as were solvent users in a variety of industrial settings.

The Southeast Jewelry Platers Project

During 1985, a DEM-funded coalition, the Southeastern Massachusetts Task Force on Environmental Management, identified the need for an inventory of platers and plating waste management in their region. Water quality in local rivers had been adversely affected by decades of uncontrolled discharges from metal plating firms concentrated around North Attleborough, Attleboro, and Taunton. New and stringent environmental controls on wastewater discharges put plating firms at risk of noncompliance. The coalition believed that opportunities existed to improve compliance, reduce waste generation, and clean up seriously polluted rivers in the region.

Based on this groundwork and a review of the industry in terms of the criteria outlined above, OSWM began putting together the SE Jewelry Platers Project in 1986. Plating processes account for over 40 percent of Massachusetts' hazardous waste streams. Wastes include cyanides, heavy metals, chlorinated solvents and acid and alkaline cleaners. The southeast region of the state has a high concentration of plating companies, most of which are small, but with a few larger companies who expressed a willingness to share their expertise. This geographic concentration allowed OSWM to design a project that would maximize the use of its limited resources. In addition, this area has a strong regional planning agency and chambers of commerce and trade associations interested in environmental issues. When the agencies and business organizations were approached, all were enthusiastic about DEM's intention to provide technical assistance and indicated their willingness to contribute to the project. Without this initial indication of support, the project would not have gotten off the ground.

The project was conceived as a two-phase effort. The first phase was intended to provide data and indemnify potential source reduction opportunities for generators in the region. Based on this research, the second part of the project would involve detailed engineering analyses and a limited program of carefully controlled process changes to evaluate source reduction effects. Funding for the first phase was obtained from a variety of agencies. The project began without funding for the second phase, but with the intention of seeking grant funds or a legislative appropriation.

Phase I

In Phase I, staff will direct their efforts at identifying all generators of hazardous waste in this industry, increase compliance among generators, and encourage generators to seek maximum levels of waste reduction and appropriate management of remaining hazardous wastes. These goals will be implemented through the establishment of a student internship program, source reduction inventories in plating shops, and dissemination of information on regulations, source reduction technologies and available funding.

Staff initially identified 102 firms as probable generators under SIC codes applicable to jewelry and precious metal plating. A subsequent telephone survey found that 76 firms actually generated hazardous waste. Others are subsidiaries of larger plating firms or suppliers to the industry that did not generate any hazardous waste. An important component of the project is the need for trained staff who will perform source reduction inventories in the shops. We chose to establish an intern program with Boston University's Center for Energy and Environmental Studies that would serve to educate Masters level students about source reduction.

The intern program consists of a five-session seminar series to be held at BU with students recruited from BU and Tufts University. The seminar covered state and federal regulations, economics and liability incentives for source reduction, electroplating, waste management and source reduction opportunity and technology. The training series culminated in three days of workshops at Taunton Silversmiths, Ltd., a precious metals plating company that has assisted DEM's waste management initiatives for years. Fourteen speakers from the University, industry and government agencies shared their knowledge with students and other attenders.

During Phase I, OSWM staff invited platers to participate in the source reduction inventory process. During the inventory process, the DEM team gathered information on inventory practices, raw material storage, process management and waste handling practices. They also scrutinized water and energy use for cost reductions, as these utility items are side benefits of adopting source reduction practices.

Project Participation

To encourage electroplating shops to participate in Phase I, we invited fifteen technical experts from the industry to serve on a Source Reduction Advisory Group. The group has met four times since 1986 and has proved invaluable in assisting the Department to scope out the project and gain access to the shops. In addition, an executive committee of the heads of the six largest companies in the region gave the project their backing and encouraged participation.

Concurrent with the inventories a series of workshops offered by DEM and the Southeast Regional Planning and Economic Development District. The workshops will offer information on hazardous waste and water discharge regulations, Right To Know requirements, source reduction technologies in use in the plating industry, and potential funding sources for project implementation. The series is expected to continue through June 1988.

The Future

While we cannot know the full potential for source reduction in the industry until we complete the inventory visits, we expect that available technologies will result in substantial reductions in hazardous emissions enabling platers to comply with stringent regulatory requirements. Whether the industry will embrace source reduction is also unknown. However, we believe that source reduction, by improving production efficiencies, not only helps companies meet their environmental obligations, but also contributes to the maintenance of their competitiveness in a global economy.

Source Reduction in the Electroplating Industry in Southeast Massachusetts: An Economic Overview

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1 Introduction

The electroplating industry is a major source of water pollution in the Commonwealth of Massachusetts. We will argue here that reduction of waste by preventing pollution from being generated at its source is an economically sensible and practical way of complementing costly pollution control programs. The electroplating industry provides a particularly attractive opportunity for waste prevention at the source in order to reduce future hazardous waste problems.

I shall begin by defining the term "source reduction" and elaborating on the types of activities involved. Second, I shall outline the benefits and costs of source reduction, focusing in particular on the problems in assessing such costs and benefits. Third, I shall sketch the characteristics of the electroplating industry in Massachusetts in terms of firm sizes, industry structure, profit margins, and capital intensity. Fourth, I shall indicate the nature of the technology of water reduction in the electroplating process, drawing attention to three new methods of source reduction. Fifth, I shall present some available data on costs and payback periods of alternative techniques of source reduction. Finally, I shall discuss the type and nature of economic incentives that will likely promote source reduction.

II. Source Reduction: Definition and Elaboration

There is no common definition of waste reduction (OTA, 1986). For general purposes, source reduction is defined as a set of on-site activities that reduce the total volume and hazard of hazardous materials used and/or generated at the facility. It does not include incineration or the pretreatment of wastewater.

The major portion of the metals and cyanides discharged by industry into the U. S. waterways derives from metal finishing

facilities, largely from electroplating processes. Of the 34 industries covered by the E.P.A.'s toxic wastewater regulations, metal finishers contribute 57% of the metals released into sewers (E.P.A., 1982). Most of such wastes in the form of metals, acids or cyanides are toxic and are potentially hazardous to biota and human health.

TABLE 1

PROBLEMS WITH DEFINITIONS OF WASTE REDUCTION AND SIMILAR TERMS

Problem #1:

Several terms currently are used to describe preferred methods of dealing with hazardous waste. These terms include:

waste reduction	waste prevention
waste minimization	waste avoidance
waste abatement	waste elimination
source reduction	

No standard definitions exist for any of these terms. Each is defined differently by each user.

Problem #2

Some definitions include **pollution control** activities as well as pollution prevention activities. Among such activities are:

1. weight or volume reduction with a corresponding increase in concentration of hazardous content.
2. onsite or offsite treatment, such as incineration.
3. offsite recycling.
4. out-of-process recycling.

The distinction between preventing waste from being generated and controlling waste after it is generated is blurred when pollution control actions are included in the definition of waste reduction and similar terms. Consequently:

* the primacy of pollution prevention is eroded,
* generators are not encouraged to consider pollution preventing activities because pollution control options are given equal standing,
* risks to health and the environment from transport and handling of waste are ignored, and
* measurements of reduction of waste generation are obscured by including the results of pollution control.

[OTA 1986, p.]

Since the definition of waste reduction will affect the design, implementation and efficiency of public action, definition of terms is important. Yet the term waste reduction means different things to different people. Table 1 (drawn from OTA, 1986) illustrates these problems. We adopt here the definition of waste reduction as in-plant practices that reduce, avoid, or eliminate the generation of hazardous wastes so as to reduce risks to health and environment. It includes the following activities (OTA, 1986, ICF, 1986):

1. Input (Raw Material) Substitution

2. Output Change (Production Reformulation)

3. Process Modification

4. Waste Reuse (When the reuse is hand piped and totally enclosed, ie, an "integral part of the process" equipment)

5. Waste Recycling (When the recycling is an integral part of the process)

6. Good Housekeeping or Good Operating Practices

The technologies listed here as comprising waste reduction should clarify the relationship between source reduction and the broad hierarchy of hazardous waste management activities. The latter refer to various means of reducing waste, which are applied after the waste is generated, outside of the process where waste is generated.

Source reduction, on the other hand, refers to in-process activities such as those listed above. Some reduce wastes by either changing the inputs, or production process, or the nature of the final product. Others focus on the reuse or recycling. Yet others modify in-site waste streams. A review of a number of studies suggests that these activities are generic to a variety of industries. There are many substantial elements of waste elimination that are transferable across industries and serve as a technical base for waste elimination concepts, so that a more rapid utilization of these experiences can take place across industrial and geographical lines. The key thing to note is that source reduction is much more of a thought process or problem-solving viewpoint that stretches back into the sources of the waste and employs engineering principles that reduce use of hazardous substance and hazardous waste and/or recover valuable materials from such wastes.

III. Benefits and Costs of Source Reduction:

A variety of benefits flow from waste prevention though it is not easy to estimate these precisely. Such benefits include:

1. Reduced Raw Material Use:
   These can be significant over time.

2. Reduced Waste Management Costs:
   A variety of savings in terms of avoided management costs result from (a) lower indirect costs of handling, storage and

treatment of disposal costs, and (b) indirect costs of insurance, legal advice, and regulatory compliance. Both of these types of costs are difficult to estimate since they are tied to the level of regulatory compliance, which may vary in the future.

3. Avoided Liabilities:
   These arise from avoided future cleanup costs of contaminated sites and future costs of victim compensation.

4. Indirect Economic Benefits:
   These benefits come in the form of: reduced exposure to hazardous materials at the workplace, more effective use of labor, energy and management resources, improved public image of the firm, etc.

The costs of waste reduction also will vary depending on the following factors:

1. Information:
   Any effective source reduction operation must be based on a source reduction opportunity inventory that obtains detailed information about the use of hazardous substances, the potential for substitution of raw material, and the impact of these on waste generation on waste generation.

2. Testing and R&D:
   This is necessary in order to assess the technical and economic feasibility and the risk to the product quality that a source reduction method poses.

3. Capital Investment

4. Training of Personnel, Management & Maintenance

5. Site-Specific Factors

6. Availability of Technology and Techniques

IV. Characteristics of the Electroplating Industry in Massachusetts

Electroplating is a process in which a product is coated with one or more layers of a metal. This process includes cleaning, etching, and activating, plating and rinsing of product. Such electroplating operations are used in the jewelry industry, the manufacture of printed circuit boards and other computer instruments, and machinery and equipment manufacturing.

Metal plating facilities vary greatly in size and character from one plant to another. For example, the surface area of products treated in a plant can vary from less than $10m^2$/day to more than $1000m^2$/day, and the number of workers employed from less than 4 to over 1000 persons. Another feature of this industry is the large number of small plants.

As the seat of the early jewelry industry, and the newer high-tech industries, Massachusetts has a sizeable electroplating industry. An unpublished 1986 report indicated the existence of 193 such firms. (What follows below as a profile of the industry is drawn from ICF [1986]). Some of these firms are "captives" in the sense that they are part of a larger production process in which they carry out the electroplating. Independent members of this industry or job shops focus on two parts of the market:

- those that focus on high margin sophisticated market niches, e.g. defense, computer and automotive industries.

- those that can respond to a larger, varied market with high volumes and low margins.

The average annual value of shipments for a firm in the state is about a million dollars.

The size distribution is indicated below:

Sales Level	% of the firm
More than $6 Million	4
$1 Million - $6 Million	33
Less than $1 Million	63

The profit margins of firms in older industry segments range from 4-5%. For firms in high-tech industries the profit margins range from 8-15%.

The cost share of materials is around 42%, suggesting that source reduction in the form of material substitution or recovery can reduce costs significantly.

V. Technology and Costs of Source Reduction

A. Electroplating Process

Most electroplating processes can be categorized into three major work steps:

(Fig. 1)

1. Surface Preparation
   This involves the cleaning of the surface before plating, usually by placing it sequentially in a solvent, or other cleanser, an acid dip, and a rinsing in water.

2. Plating Application
   The part to be plated is placed in a solution and charged with electricity so as to attract the dissolved metal and is then rinsed again in water. This step may be repeated several times to build up protective and/or decorative layers.

3. Post Treatment
   In some cases, this step is undertaken for coloring or for adding corrosion resistance.

Contaminants in the effluents from electroplating shops originate in different ways:

(a) discharge of polluted rinse water

(b) discharge of spent treatment baths

(c) accidental spills and leakages

WORK STEPS

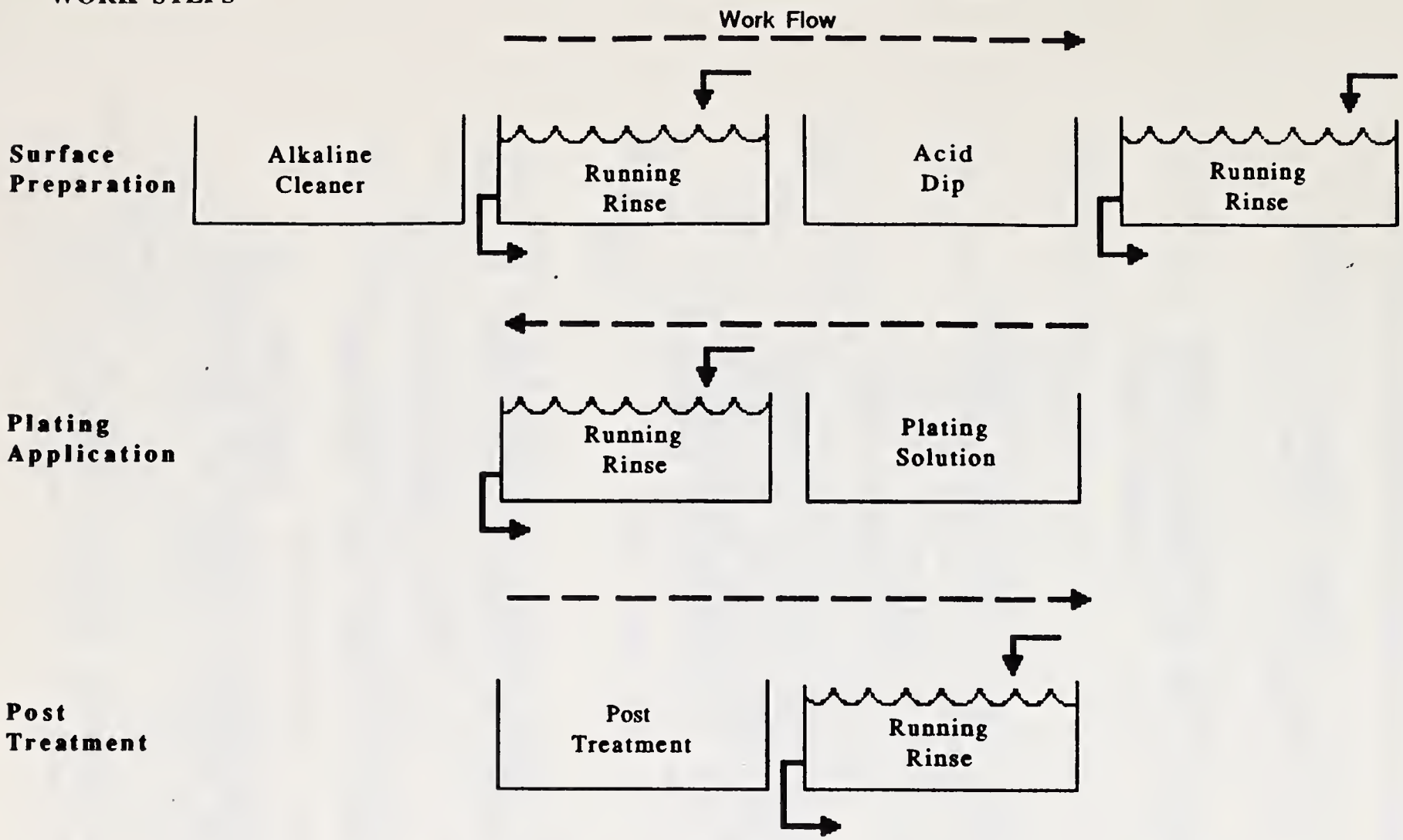


Figure 1 Overview of Electroplating

Source: Salzenberg, 1982

In almost every case, the most significant pollution problem is "drag-out" (chemicals dragged out of plating baths when the plated item is removed) and the resultant contaminated rinse water. For example, 22 electroplating shops in Cleveland discharged 18,500 gallons per day (gpd) on an average, while spent process solutions accounted for gpd (EPA, 1982).

Table 2 lists typical raw loads of waterborne residuals, corresponding to the cases when these compounds are constituents of process baths.

TABLE 2

RAW LOADS OF WATERBORNE RESIDUALS IN THE METAL PLATING INDUSTRY

Waterborne Residuals	mg/l	mg/sq m *
Zinc	10 - 50	4,000 - 30,000
Nickel	2 - 15	800 - 9,000
Copper	5 - 15	2,000 - 30,000
Chromium (VI)	10 -120	4,000 - 72,000
Cadmium	10 - 50	4,000 - 30,000
Iron	1 - 10	400 - 6,000
Cyanide (total)	1 - 50	400 - 30,000
Phosphate	20 - 50	8,000 - 30,000
Total Suspended Solids	4 -600	1,6000 -360,000
(pH)	4 -10.5	4 - 10.5

(*) Estimated on an average water use per square meter plated of 400 - 6,000 liters. This figure for water use may be greatly reduced in advanced technologies.

Source: OECD 1983, page 31

Waterborne residuals of the metal plating industry may be controlled by the following methods:

(i) "End-of-pipe" treatment of raw waste water. Since the capital cost of conventional equipment to treat this waste water is directly related to the volume of water, traditional methods of rinse reduction were designed to reduce rinse volumes by reducing the drag-out from process baths to the rinse tanks. However, such techniques often fall short of water quality standards which are becoming increasingly stringent.

(ii) Newer methods of pollution reduction at source. These involve solvent substitution, plant/process modification, resource recovery and water conservation.

We discuss below both types of methods. Although chemical treatment techniques at the "end-of-pipe" stage can markedly reduce emissions, progress to high levels of pollution control is possible with

source reduction methods. Such higher levels of control are also efficient in terms of reduced material and water costs.

Section III B. briefly describes the conventional pollution control methods and their economic characteristics. Section III C. presents similar information on the newer source reduction technologies.

B. Conventional Pollution Abatement Technologies

There are a variety of commonly used technologies for reducing the discharges of most of the pollutants generated by the metal plating industry to very low levels. A few basic chemical processes can tackle most effluents (OECD 1983).

1. Oxidation of cyanide

2. Reduction of hexavalent chromium and

3. Neutralization and precipitation of metals

Standard reliable and separate processes for cyanide, chromium VI and neutralization of metal are available. A representative system showing automated continuous flow is shown in Figure 2.

The neutralization and precipitation processes generate a "sludge". The prospects for recovering metals in-house (e.g. copper, nickel, chromium, etc.) from such a mixed-metal sludge under conventional methods are not good.

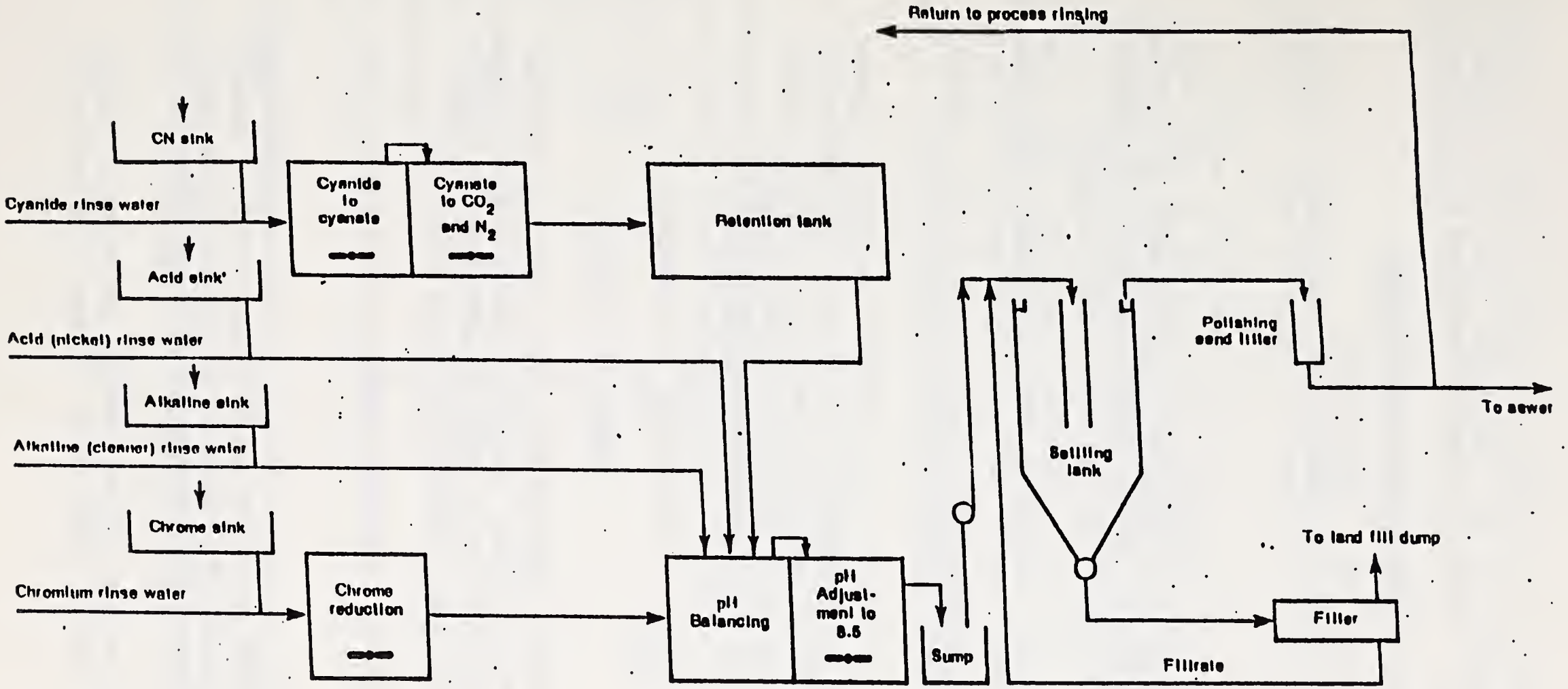
Typical treatment costs for conventional technologies, in small, medium and large electroplating shops (as indicated by volume of waste water generated) are presented in Table 3.

TABLE 3

END-OF-PIPE TREATMENT COSTS

TOTAL FLOW RATE (GALLON/DAY)	16,665	50,000	5000,000

Figure 2 **AUTOMATED CONTINUOUS FLOW TREATMENT FOR CHROMIUM, HEAVY METALS AND CYANIDE WASTE**



Source : «Review of the Canadian Metal Finishing Industry», EPS 3-WP-75.2, Environment Canada 1975.

Source: OECD 1983, p. 36

LEAST COST SYSTEM	Batch	Batch	Continuous
INVESTMENT COSTS:			
Wastewater Treatment	96,142	$145,166	$431,143
Sludge handling *	22,600	39,000	247,000
Total Investment:	118,742	84,166	678,143
ANNUAL COSTS:			
Capital Costs	7,576	11,750	43,266
Depreciation	23,748	36,833	135,638
Operation & Maintenance Cost (Excluding Energy & Power Costs)	7,555	19,731	33,267
Sludge Handling O&M	4,278	4,278	63,0(
Total O&M	11,833	24,009	46,26
Sludge Hauling	1,557	4,680	46,800
Energy & Power Costs	627	1,341	1,057
Total Annual Costs	**$45,341**	**78,613**	**273,018**

* It should be noted that sludge generation and disposal cost have risen at a rate considerably exceeding that of inflation.

C Newer Methods of Waste Abatement: Source Reduction

The primary sources of waste water in the electroplating industry are the different rinsing operations. There are many in-process measures designed to reduce the volume of waste water. Certain measures such as counter flow rinsing (Fig. 3) which reduce the rinse rate needed for adequate removal of the process solution and the single drag-out method for recycling drag-out are part of normal practice today. The newer methods described have extended these techniques for waste reduction. Dew recommends up to 4 counter current rinses or drag outs. In same instances it is possible to close-loop the individual plating lines with these techniques.

Generally, such "in-process" or "process-integrated" control measures can be broadly grouped as:

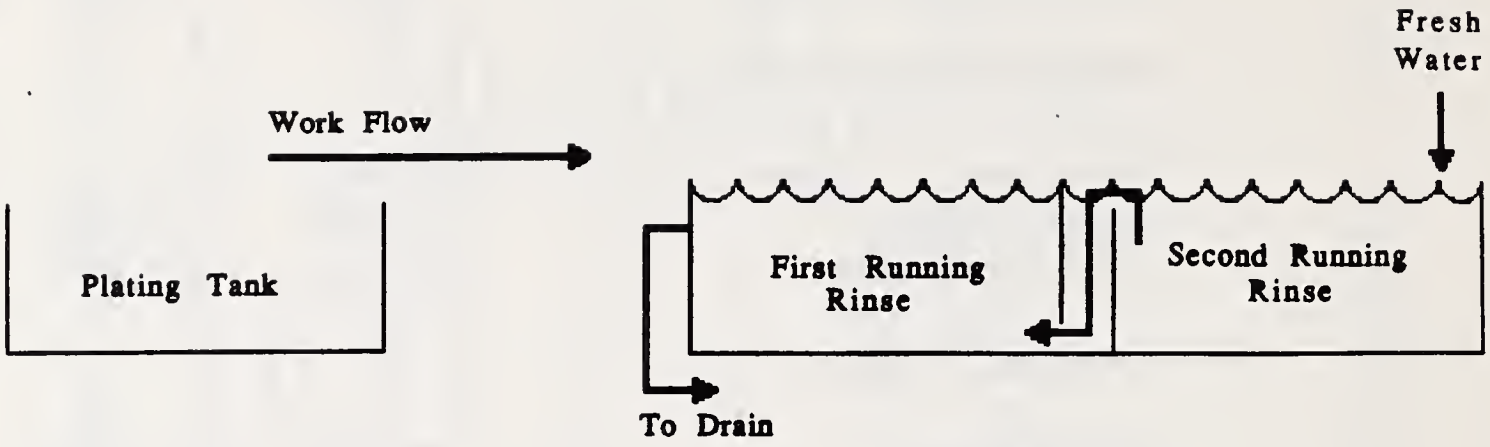


Figure 3 Counterflow Rinsing

Source: Salzenberg, 1982

(i) Recycling rinse water

(ii) Process modifications and material substitution

(iii) Recycling of chemicals

(i): Advanced rinsing techniques are available to achieve a drastic reduction (around 99%) in plant water discharge concentrations. They include:

- static rinsing, where the water can be recycled to the plating vat leading to recovery of raw materials and less use of water.

- multiple drag-out (Fig.4) -as a rule of thumb, each drag-out task reduces the discharge concentration by 50%.

- spray rinsing, drip racks and drip boards.

- evaporative recovery. A systems approach combining several of these techniques can lead to closed-loop plating lines.

(ii): It is possible to reduce the emissions from degreasing and metal plating operations greatly if the bath composition is changed. For example, a variety of surface active compounds can be substituted for phosphates. A second method is to use a number of bath solutions that use lower concentrations of zinc, cyanide, chromium acids or other raw materials.

(iii): A variety of technologies exist for the recovery of specific metals. They include ion-exchange processes, membrane techniques (reverse osmosis), electrolysis, and evaporation. These processes can be used singly or in combination to extract chemicals from the effluent and to purify effluent water so that chemicals and water can be recycled. In this connection, a new promising process has been imported from Poland. The trade name of the system is FKJA. The treatment chemical is a formaldehyde-based solution that oxidizes most metals instantaneously into an insoluble state (Saltzenberg 1982, see Fig.5). Copper and silver precipitate in elemental form, and periodically the deposit tray containing precipitated metals can

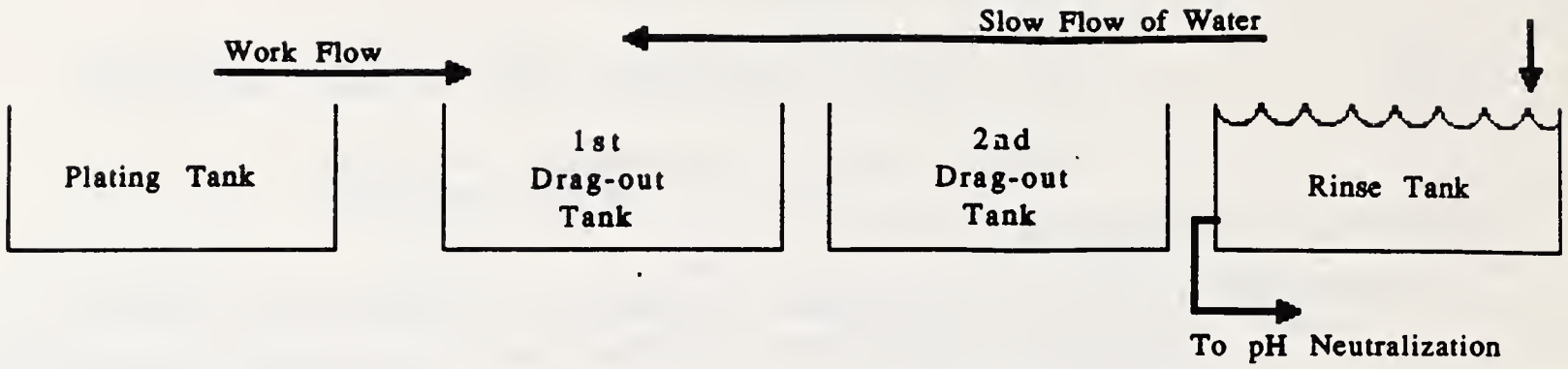


Figure 4 Multiple Drag-out

Source: Salzenberg, 1982

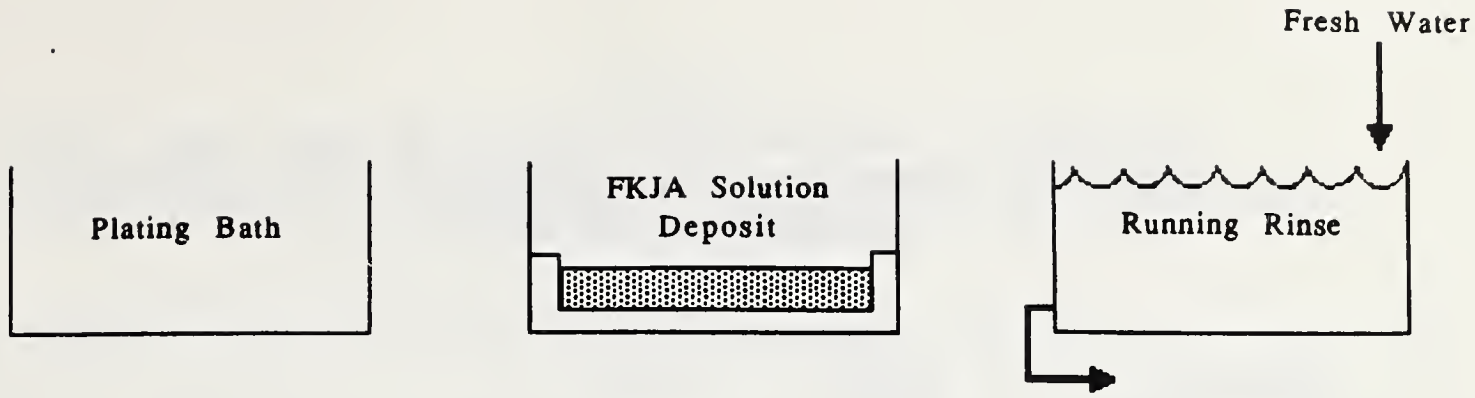


Figure 5 Polish Waste Recovery System

Source: Salzenberg, 1982

be emptied. After the FKJA process, the rinse water can be discharged without further treatment.

TABLE 4

COMPARISON OF WASTE REDUCTON ALTERNATIVES FOR A MEDIUM SIZE ELECTROPLATING FIRM

	1. Baseline	2. Standard Methods	New Methods Moderate	New Methods Extensive
Process Assumptions				
- Number of process lines	5	5	5	5
- Number of rinse stations	20	20	20	20
- Number of fresh water fee lines	20	20	10	7
- Rinse water flow rate	48,000 gpd	20,000 gpd	5,000 gpd	8,000 gpd
In-Process Control Capital Costs				
- Counterflow rinse tanks	-	$24,000	0	0
- Air agitation	-	1,200	1,200	1,200
- Flow control valves	-	200	110	110
- Drag-out tanks	-	-	1,800	1,800
- Piping/pumps	-	-	1,000	1,300
SUBTOTAL	0	$25,000	$4,110	$4,410
Final Treatment Capital Costs				
- End of pipe	$145,000	$100,000	-	-
- Batch dumps	-	-	60,000	60,000
- pH control	included	included	4,000	4,000
Total Waste Control Capital Costs	$145,000	$125,400	$68,110	$68,410
Total Annual Cost	79,000	45,000	29,000	23,000
Payback Period	none	12.5 yrs	5.73 yrs	4.75 yrs

TABLE 5

COST OF THE WASTE REUSE PROGRAM AT A LARGE METAL FINISHING JOB SHOP IN NEW ENGLAND

	Baseline (Projection)	Standard (Projection)	New Methods (Actual Cost)
Process Assumptions			
- Number of process lines	11	11	11
- Number of rinse stations	50	50	50
- Number of water feed lines	50	50	27
- Rinse water flow rate	140,000 gpd	60,000 gpd	40,000 gpd
In-Process Control Capital Costs			
- Counterflow rinse tanks	-	$30,000	2,400
- Air agitation	-	3,000	3,000
- Flow control valves	-	250	250
- Drag-out tanks	-	-	4,000
- Piping/pumps	-	-	3,000
SUBTOTAL	0	$33,250	$12,650
Final Treatment Capital Costs			
- End of pipe	-	$145,000	-
- Batch dumps	-	-	60,000
- pH control	included	included	4,000
Total Waste Control Capital Costs	$468,000	$178,250	$76,650
Total Annual Cost	212,000	91,400	29,000
Payback Period	none	6.75 yrs	2.32 yrs

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Source Reduction in Southeast Massachusetts

Brenda Reed
Governor's Office of Economic Development

My objective is to provide you with an introduction to Southeastern Massachusetts that I trust will offer some insight into the history and status of the plating industry in the region. As the former Mayor of Attleboro, and as the regional coordinator for the Governor's Office of Economic Development, I believe I can offer you a unique perspective.

Southeastern Massachusetts covers five counties (Barnstable, Bristol, Duke, Nantucket, Plymouth), five cities, and sixty-five towns with a combined population of approximately 1.1 million people. The region is one hour from Boston and approximately 200 miles from New York City. Linked by Interstates I-95 and I-495 to the Massachusetts Turnpike, the area is within an overnight drive for 35% of the nation's population.

Southeastern Massachusetts is the fastest growing region in the Commonwealth. The completion of I-495 has served as the catalyst for new interest in Southeastern Massachusetts: a number of major Route 128 corporations have broken the mold and moved beyond the confines of the Boston region. According to statistics released by the Center for Massachusetts Data, University of Massachusetts at Amherst, this growth pattern is expected to continue through the year 2000.

While the Commonwealth's population growth is projected to increase in the eighties by 3.2%, Southeastern Massachusetts projects a 12.9% growth. This regional growth targets the small towns primarily, with Taunton being the only larger Southeastern Massachusetts city projected for significant change. The remaining cities will change slightly, their growth coming in the form of recovery from population losses.

Projected Population Growth
for S. E. Massachusetts & State 1980-1990

	1990	1980	% Change
Massachusetts	5,918,106	5,737,037	3.2
Southeastern Massachusetts	1,176,069	1,042,032	12.9
Barnstable	191,820	147,925	29.6
Bristol	497,371	474,641	4.8
Duke	12,004	8,942	32.8
Nantucket	6,573	5,087	29.2
Plymouth	468,301	405,436	15.5

Source: Center for Massachusetts Data, University of Massachusetts at Amherst

The employment rate in the region, with the exception of Fall River and New Bedford, is in keeping with the state average. Unemployment in the two identified cities is expected to decrease as new company inquiries become actual company placements.

In the past year, Plymouth and Bristol Counties have reported 7,000 new jobs each in the non-manufacturing sector while registering a manufacturing job loss of 830 in Plymouth County and 3,500 in Bristol County. The employment growth is occurring in trade, construction and services.

In an effort to understand and address the concerns of the Southeastern Massachusetts region, my office conducted a survey in the summer of 1986. The survey was mailed to selectmen, planners,

administrators, chambers of commerce and economic development entities in the region. We received a 44% response from those receiving the questionnaires. Growth management topped the list of concerns, followed closely by infrastructure, affordable housing and regional economic development. The survey has become a useful tool in helping people who are expressing an interest in the area to understand the region's evolving dynamics.

SOUTHEASTERN MASSACHUSETTS SURVEY

Results:

Percent	Major Concern
58	growth management
58	infrastructure (roads, sewers)
48	solid waste disposal
46	affordable housing
34	regional economic development
29	water quality and/or protections
26	incentive aid
21	federal revenue sharing-loss
16	master planning
13	insurance costs-liability
6	training labor force
4	hazardous waste

In the late 1970's , when the region experienced an extraordinarily high unemployment rate, leaders recognized that there was a need to diversify. As the textile industry was hit hard by off-shore operations, leaders realized that they must begin to work together in an effort to turn the economy around. Now in the mid-80's we find extraordinary growth in Southeastern Massachusetts, an economy that has bounced back significantly since that late 70's , with a burgeoning regional cooperative effort. In the region we are receiving inquiries from new companies, out-of-state companies, international firms and financial services organizations considering relocation or expansion here. People are moving here from the North Shore and other parts of the state as they find that the highway network allows them to live in the area and work at another location.

Growth and relocation are accompanied by the need for responsible management. This comes at a time when regulatory agencies are imposing stronger guidelines for developers, municipalities and business people. I firmly believe, however, and have always been a strong supporter of the concept that <u>economic development and a quality environment can co-exist.</u> It must be a cooperative effort, a public/private partnership based on responsible management.

That brings us to the source reduction project. Why is this project important to the Attleboro area and the section of Southeastern Massachusetts that surrounds it? Let's take a moment to review the history of industry in the Attleboro area.

The Attleboro area has one of the healthiest industrial climates in New England. Its strength is based not on a single dominant industry or firm, but on a variety of interests serving both consumer and industrial markets. The relatively small city of Attleboro, population 35,000, has an enormous industrial base. Over 17,000 manufacturing jobs make it one of New England's largest industrial employers - the 9th largest in the Commonwealth of Massachusetts.

As early as 1742, Robert Saunderson established the "Bloomery" for the manufacture of iron wares in Attleboro. Comparatively large scale industrialization appeared in the early

19th century when the textile industry became prominent in the area. As a matter of fact, the little "fruit of the loom" guys were born at the Hebronville Mill in the Hebronville section of Attleboro.

Jewelry production, mostly in the form of uniform and ornamental buttons, started as early as 1790. By 1850 buttons had become big business. Shortly after that, the jewelry industry expanded rapidly in size and scope, taking its place as the largest concentration in the nation of jewelry and related trades. Through the years, people have referred to the Attleboro area as "the birthplace of the jewelry industry in America" and "the hub of the jewelry universe". This industry has literally served the markets of the world.

The economy was so strong, I am told, that if you lived and worked in Attleboro during the depression years, you could be totally unaware that a depression actually existed. Since that time Attleboro has adapted to a vast range of products, initially metal, later expanding into ceramic and man-made materials.

That, I believe, gives you some sense of the Attleboro area. How then did the different groups come together for the source reduction project?

In June 1986, the governor met with a group of company executives during an "innovation" stop in Attleboro. The discussion that day included soon-to-be imposed EPA regulations, regulations geared toward companies whose effluents were transported to the Ten Mile River either directly or through a water pollution control facility. At that time company executives indicated that they would be hard pressed to meet the regulations, feeling that the compliance technology simply didn't exist. At that meeting, I informed the governor that I was arranging a July I meeting with local business leaders. The goal of that meeting would be to form a task force whose duty would be to assist area companies with their compliance concerns.

While all of this was happening Lee Dane from the Department of Environmental Management had been working on a source reduction proposal which targeted the plating industry in Southeastern Massachusetts. Because Lee was still seeking funding for the project, and because we now had a problem with the new EPA regulation, we were brought together and decided this was not a

problem at all: it was an opportunity for interagency cooperation and a public/private partnership.

Since then we have been able to gain the support of the major firms in the Attleboro area through their CEO's and the support of the Attleboro Chamber of Commerce. We have coordinated funding for Phase I of the project through the Massachusetts Department of Environmental Management, the Department of Commerce and Development, the Executive Office of Environmental Affairs and the Executive Office of Economic Affairs.

Why are we doing this, you might ask? We are doing this certainly because of the new regulations, but we are doing this because it affects cities and towns, it affects business, (approximately 100 businesses with 15,000+ employees), and it affects people.

While Attleboro currently has a pretreatment program for industry, at this point they cannot be sure that they will be able to comply with the new regulations. Possible additional plant construction would ultimately be borne by the consumer (business and residential), through taxes and /or sewer rate increases.

To give you some comparison of what the cost might be, the original plant construction was $27 million plus. This cost was largely underwritten by the government. The community paid 10%. Grants, however, have been scaled back by the government and while the new Clean Water Act (just passed by an override of the President's veto) could help, the Act at this time is a Congressional authorization that is not accompanied by an appropriation. A tax increase represents an impact to the municipality - but what about the firms?

The list we are using for the purpose of this project contains 102 plating companies. A further breakdown of that list reveals that fifty-two companies or 51% do not have an EPA I.D. number. Seventy-four companies have less than 75 employees. Fifty-one, or 69% of these companies have no I.D. number. Fifty-seven companies have less than 40 employees. Forty-four or 77% have no I.D. number. These companies are probably companies which are putting high concentrations of toxics into the sewer system. As you can see, the majority of these firms are rather small firms. So how do they deal with the issue of compliance? What costs are they facing? Here are a few examples.

- a Norton company with 10 employees and annual gross sales of $450,000 spent $100,000 on a waste water facility.

- a major Attleboro firm with 3000+ employees spent ready tax million dollars on a wastewater facility.

- a major Attleboro firm with 1000+ employees has estimated that compliance with the EPA regulations for the Ten Mile River will cost them more than a million dollars.

As you can see, the numbers are staggering. But there are also significant economic effects if our small quantity generators cannot comply with the regulations and have to shut their doors. Let me give you an example. Recently, in Fall River, as a result of the Kerr Mill fire, approximately 900 people were placed temporarily out of work. In Fall River, a community of approximately 95,000 people, a variety of agencies from all areas of government and individuals from different areas of the private sector came together to provide temporary assistance for the workers during the time they would be unemployed while the mill was rebuilt. That in itself was a major undertaking. Similar efforts would be necessary in Attleboro if our small quantity generators were unable to meet their regulatory obligations. The major difference would be that we would not be looking at short-term relief but, rather, a major and permanent reconfiguration of people's lives. The impact would go beyond dollars and cents. It could strike a devastating blow to this small city.

It is certainly to everyone's benefit to seek new and innovative ways to achieve compliance. Source reduction is a common sense approach that can hopefully ensure the continued operation of these companies.

As you can see,

- With major growth expected to continue in S.E. MA

- With regulations becoming more stringent

- With the knowledge that companies must seek the competitive edge to survive and prosper

We need now, probably more than ever before, to work together

- to develop public-private partnerships
- to see ourselves as both instructors and students
- to help one another
- to help ourselves

I'm very enthusiastic about this project. I really like the hands-on experience we will all be able to have. When the project is done, we will have learned and shared and broadened the range of those companies coming into compliance and remaining competitive.

Optimistic? Yes. But I honestly believe we are embarking on something significant and that we are in the process of developing a workable model that will be used by others in the future!

Environmental Law

Henry Henderson, Boston University

Introduction

I want you to know that my perspective with regard to this subject matter is that of a planner and not that of a lawyer. As I provide you with a planning perspective, maybe I can offer you some useful ways to think about the issues before us. It is my understanding that the subsequent speakers do indeed come from a more legal perspective, and perhaps they can complement my discussion.

Next, let me add that I will not be reviewing the entire field of environmental law, but rather two key aspects relevant to source reduction in the electroplating industry.

The body of environmental law has grown rapidly and, as most people are aware, there was a major thrust in the establishment of statutory environmental law in the United States at the federal level in the late 1960's and early 1970's. A lot of people ask why environmental law attracted so much attention at that particular point in time. First, from the supply side, we were beginning to see some payoffs from prior research investments, monographs that identified ecological systems and research on the environmental fate and effects of various pollutants. Second, from the demand side, because of Rachel Carson and others, there was an increase in public awareness about the ways in which the environment is affected by human behavior and actions.

I will limit my comments to two areas - water pollution and hazardous waste. My comments will necessarily be general,and as a result will omit a fair amount of detail. My aim is to provide you with a characterization of the legal background and strategy of the environmental law in these two areas.

Water Pollution

The United States really did not have an effective legal response to water pollution until the 1960's and 1970's. While the

Refuse Act of 1899 actually prohibited the discharge of refuse into navigable waters without a permit from the Army Corps of Engineers, it was not much utilized. It was not until the Federal Water Pollution Control Acts that we began to develop an alternative federal approach to water pollution control.

Now, let me distinguish between the Act prior to 1972 and the Act after 1972. This distinction enables us to see a rather substantial shift in the legal strategy utilized in the United States with regard to water pollution control. Prior to 1972, the approach was largely driven by the federal government cooperating with the states. The states were to classify their water bodies according to appropriate use (e. g. a cultural use, industrial use, recreational use, etc.) That use classification would indicate the appropriate types of ambient water quality standards for each use. However, the entire water pollution control effort prior to 1972 failed, largely as the result of either lack of or infeasibility of enforcement. The system was subject to the same types of problems we have in more traditional nuisance law. For instance, with multiple polluters in a particular stream or body of water, it is very difficult to prove which of those polluters is ultimately responsible for the failure of the body of water to meet ambient water quality standards. Further, in the pre-1972 system, the federal government's role was limited to enforcing against violators of the water quality standards.

In 1970, the federal government began a program to establish a new permitting process based upon the Refuse Act of 1899 and the permits that the Army Corp of Engineers had the power to issue. That effort was put on hold by an environmental suit relying upon provisions in the new National Environmental Policy Act requiring environmental impact statements. Before this challenge was resolved, in 1972 Congress passed major amendments to the Federal Water Pollution Act that completely restructured the legal strategy with regard to the control of water pollution in the United States. The new system consisted of a series of standards associated with the discharge of pollutants into bodies of water, a system of permits required for discharges, and a substantially enhanced enforcement role for the government with regard to discharges without a permit or not in accordance with the permit.

In Section 301 of the 1972 Federal Water Pollution Control Act a distinction was made between industrial discharges, or point sources, and municipal or sewage treatment plants, public point

sources, called publicly owned treatment works (POTWS). All industrial point sources were expected to meet a standard called "best practicable technology" (BPT), by 1977. Such sources also were supposed to meet a more stringent set of technical standards, referred to as "best available technology economically achievable" (BAT) by 1983. Industrial point sources were also required to meet more stringent discharge limitations if they had been established by the states or pursuant to Section 302 in the 1972 amendments, which concerned the achievement of comprehensive water quality standards.

POTWs, or municipal sewage treatment plants, were dealt with somewhat differently. By 1977, according to the 197[illegible] Act, POTWs were to meet secondary treatment standards. By 1983, they were to meet BPT standards over the life of the POTW. Section 306 of the 1972 amendments addressed new sources, (those constructed after 1972), and required their effluent limits to meet the higher BAT standards.

Section 307 of the 1972 amendents dealt with toxics in water. EPA was required to develop a list of toxic substances and to establish separate limitations for the substances on the list. The standards for effluent limitations for each toxic substance in the Act were to be based on the protection of public health and water quality rather than on technological feasibility. I emphasize this point to show you the differences in the legal strategy. The discussions of BPT and BAT in the 1972 Act amendments suggest economic and technical criteria for "conventional" discharges. On the other hand, where the toxic substances were concerned (Section 307) the strategy was to be based on public health and water quality rather than technological feasibility. Section 402 of the 1972 Act established a permitting system known as the National Pollution Discharge Elimination System (NPDES). Permits were to be granted by either the Environmental Protection Agency or by states with approved EPA programs. Any point source discharge without a permit or not in compliance with permit limitations was declared unlawful. Permits had to incorporate the applicable effluent limitations established by the sections of the Act mentioned above.

The 1972 Act contemplated that each state would have a primary enforcement role, but retained to the EPA authority to act where the states did not. Provisions allowed for inspection, entry, monitoring, federal enforcement and emergency response. The 1972

Act, by virtue of section 505, also enables citizens to sue for enforcement of effluent limits under state or EPA permits and orders, or to sue the EPA for failure to perform nondiscretionary duties.

I would like to mention the fact that non-environmental questions often tend to become the focus of the development of environmental law. For example, a Section 505 citizen suit regarding EPA and its non-discretionary duties may get involved in a morass of questions on what constitutes discretionary vs. non-discretionary duties, administrative procedures, etc. The merits of the environmental question may not be examined at all.

The Federal Water Pollution Control Act of 1972 was substantially amended and redesignated in 1977 as the Clean Water Act. The Environmental Protection Agency was authorized to extend on a case by case basis the BPT standard to industries that had demonstrated that they had made a good faith effort to comply with BPT. Thus, good faith actions did not yet have to meet BAT. Also, EPA could grant waivers for up to 6 years from secondary treatment standards to POTWs when the inability to achieve secondary treatment was related to a lack of federal construction grant funds.

The BAT compliance requirements in 1977 were complex, to say the least. Remember that in the 1972 Act, by 1983 all industrial and new municipal point sources were to meet best available technology standards, a set of standards somewhat higher than the best practicable technology standards. In the 1977 amendments Congress divided the changes in this area into three categories - changes associated with toxic, conventional, and non-conventional pollutants entering bodies of water. With regard to toxic pollutants, the best available technology standards were to be achieved by 1984. If the pollutant was not on the original list of toxic substances generated by these amendments, best available technology had to be achieved three years after EPA had adopted applicable effluent limits for that toxic substance. No exceptions were allowed. EPA was authorized to adopt more stringent standards than best available technology for some toxic pollutants, up to and including zero discharge.

For conventional pollutants, a new category was established. (Conventional pollutants may be chloroform, pH, biological oxygen demand, etc.) A new standard was created, best conventional

pollutant control technology, or BCT. These were to be achieved by 1984 for conventional pollutants, according to the 1977 amendments. In establishing the effluent limits for conventional pollutants, EPA must consider, among other things, the reasonableness of the relationship between the costs of and benefits from attaining a reduction of effluents. In other words, you see creeping into BCT effluent limitation standards an increased concern for cost benefit analysis. This factor was not to be considered, I remind you, for the best available technology limits for toxic pollutants, nor for the third category, nonconventional pollutants.

For nonconventional pollutants, best available technology standards were to be achieved within three years after the limitations were established or by 1984. Nonconventional pollutants were those that were designated neither toxic nor conventional.

Under Section 3016 of the 1977 Clean Water Act, EPA, with state concurrence, may extend the deadlines to 1987 if the extension will not interfere with the attainment of water quality standards or pose an unacceptable health risk.

In sum, the legal strategy in water pollution control is that of either a health-based or a technology-based discharge-limiting permit approach with some opportunity for consideration of feasibility factors such as economics. Remember, at the time the 1977 amendments were passed in Congress, there was a great deal of political disagreement over the extent to which economic feasibility should be taken into consideration by the Environmental Protection Agency. The 1977 amendments reflect the political compromise achieved at the time. For example, the standard of best conventional technology incorporation of economic considerations was established for most conventional pollutants, but such considerations were avoided in the toxics area.

Hazardous Waste

Let me now proceed to hazardous and toxic wastes. First of all, the term hazardous waste means any combination of wastes which pose substantial present or potential hazards to human health or living organisms. Let me note also that the determination of hazardous and toxic substances is characterized by a problem with significant legal implications. There is a pervasive scientific uncertainty about the long term human effects of exposure to small

amounts of such substances. In the face of this uncertainty, rules concerning such phenomena as risk assessment, causation, presumptions, burden of proof, and the scope of judicial review become critical to the legal approach.

To give you some idea of the magnitude of the waste disposal problem, in 1984 the Thirteenth Annual Report of the Council of Environmental Quality (CEQ) stated that in 1983 the United States produced about 250 million tons of hazardous wastes -- a significant escalation from the 44 million ton figure used just a few years previously. By 1984, EPA had identified some 17,000 hazardous waste disposal sites, 539 of which were on the original list of priority sites scheduled for cleanup under Superfund.

Prior to 1970, the United States operated under the Solid Waste Disposal Act, which was by no means a comprehensive regulatory scheme with regard to hazardous wastes. The Resource Recovery Act of 1970 did not establish any regulatory responsibilities, but Section 212 required that EPA prepare a comprehensive report to Congress on the storage and disposal of hazardous wastes, plan a system of national disposal sites, recommend methods of waste reduction, neutralization and recovery, and control exposures to hazardous waste materials. The report, entitled A Report to Congress: Disposal of Hazardous Waste was published in 1974. EPA relied upon consultant studies that attempted to compare alternative methods of hazardous waste management and to evaluate the alternatives from economic and legal perspectives. In my judgement their reports were fairly short on evaluation of alternatives from a legal perspective and furthermore, the alternatives examined were neither extensive nor creative.

By the mid-seventies, there were 13 different pieces of federal legislation directly related to hazardous and toxic waste management. For instance, in addition to the Clean Air Act and the Clean Water Act, there were various provisions in the Atomic Energy Act of 1954, the Transportation of Explosives Act, the Hazardous Materials Transportation Act of 1970, Civil Aeronautics Safety Regulations, the Hazardous Cargo Act, the Federal Hazardous Substance Labeling Act, the Federal Insecticide Fungicide and Rodenticide Act, the Marine Protection Research and Sanctuary Act of 1972, the Poison Prevention Packaging Act, and the Food, Drug, and Cosmetic Act. In addition, there was generic language in the National Environmental Policy Act, passed in 1969, that could be used to

embrace hazardous and toxic substances as well. Congress responded to the need for comprehensive regulation of hazardous and toxic wastes through the 1976 Resource Conservation and Recovery Act (RCRA). First of all, RCRA requires the administrator of EPA to promulgate criteria to identify hazardous wastes, taking into account toxicity, persistence, and potential bio-accumulation as well as other characteristics such as corrosiveness, reactivity and flammability. After the establishment of the criteria, EPA was given broad authority to generate lists of hazardous wastes and to promulgate such standards as may be required to protect human health and the environment. Separate standards pertain to generators, transporters, and disposal sites.

The heart of RCRA is a waste manifesting system designed to track wastes from "cradle to grave". The generator standards of Section 3002 involve record keeping, reporting, labeling and the use of appropriate containers. The manifest system is established to ensure that the hazardous waste generated by the sources are legally processed onsite or at a facility with a Section 3005 permit to operate a disposal facility. The system is intended to ensure the monitoring, reporting, and categorizing of all hazardous wastes from creation to "eternity" in some cases. A form, called a manifest, follows a waste wherever it goes, and copies of the form are deposited with federal and state authorities. Manifesting, keeping records of transactions, and labeling are also required of hazardous waste transporters.

The treatment, storage, and disposal facility standards go beyond the manifest system to require specific disposal methods, to restrict siting, to institute strict construction standards, and to provide for the safe operation and closure of disposal facilities.

In Section 3007, EPA is given broad power to inspect and issue compliance orders with permits issued under Section 3005. EPA can bring civil or criminal actions against violators of permit requirements or for falsifying documents under Section 3008D. Section 3006 of RCRA wed the Federal Government to the states in terms of implementing the program. States may assume responsibility for the administration of a hazardous waste control program if the state program has been approved by the EPA. Section 3009 of RCRA provides that state laws less stringent than the federal laws are preempted by the federal law.

Section 7003 gives EPA the authority to seek injunctive relief under certain circumstances. For instance, upon receipt of evidence that a solid or hazardous waste represents an imminent or substantial danger to health or the environment, the administrator may bring suit to restrain immediately or to take such other action as may be necessary. The power conferred on the EPA administration by RCRA is sweeping, and EPA has not failed to use it.

Standards for facilities fall in general into two categories, those applicable to disposal facilities such as landfills or incinerators, and those applicable to treatment and storage facilities.

A few days after his re-election, in 1984, President Reagan signed the first substantial piece of environmental legislation of his administration. This was the Hazardous and Solid Waste Amendments of 1984 or HSWA. HSWA does not fundamentally alter the cradle-to-grave manifest system legal strategy established by RCRA, but rather closes loopholes. Among the issues addressed in the 1984 amendments are disposal by small quantity generators. In the original act generators of hazardous substances of less than 1000 kilograms (kgs) per month did not come under the purview of EPA. According to the 1984 amendments, EPA is given authority to establish generation and disposal standards for generators of less than 1000 kgs per month. If EPA does not do so by a certain deadline, generators of between 100 and 1000 kgs will be required to meet the same standards that apply to the generators of over 1000 kgs per month.

Another corrective measure was permit life. The amendments in 1984 established permits for no more than 10 years, and require facility permits for land disposal of hazardous wastes to be reviewed at least every five years. In addition, there are new types of enforcement measures and criminal penalties. There are new provisions permitting continuing releases from existing facilities. There are limits on land disposal methods. For instance, if the EPA fails to meet a deadline period as stated in the 1984 amendments, some land disposal techniques will be statutorily prohibited altogether.

In summary, the legal strategy being followed in the area of hazardous waste disposal is technology based and provides for little or no consideration of feasibility or economic factors.

Hazardous Waste Law

George Furst, U. S. Environmental Protection Agency

My introduction to environmental work was as a graduate student at Penn State back in 1970. I was a geologist working on my doctorate in geochemistry, trying to determine why toxic material was getting into a well system in the valley where I worked. It was very interesting because at that time there was no work done like this at the federal level. Our project lasted for about a year until industry found out that we were publicly supported by the university, and that we were gathering evidence to bring industry to court on pollution of groundwater resources. Immediately the political base for our whole program was gone. I believe this experience shaped some of the environmental groups I worked with. Some of those people now work in environmental defense funds and similar activities.

I went into industry after finishing my doctorate at Penn State mainly because I wanted to understand how industry works. I worked for about eight years as an environmental chemist and as a materials specialist at the Norton Company in Worcester, MA, a large manufacturer of grinding wheel diamonds. It was a very interesting process to be involved in that whole system in Western Massachusetts, requiring industry to clean up the mess they had made, the drums and the waste that had accumulated on their sites over the last 30 or 40 years. The generation that preceded your generation never even thought that these things would come back to haunt us, so this is the legacy that we are working on now and it's part of the reason that I'm in the agency.

I want to premise my presentations by saying that this project is a seed bed of very important environmental work. Awareness of reality in the classroom is good for one of two things. It either makes you want to stick your head in the sand like an ostrich and say, Oh my god! or you get a sense that we must do what we can, let's start early, let's spend our time to learn what needs to be done. I think this is the seed we are planting in a program like this. I want to introduce the subject in this manner because that's where I came from. A lot of my commitments in environmental work are because I saw what was happening, I worked in industry, I realize what the

bottom line means, and I realize now working in the agency some frustrations and some of the limitations we have in the environmental area.

What I have handed out to you is the handbook for small quantity generators. I handed this out for two reasons. One is I am not the EPA expert on small generators. I had to read this to learn what a Small Quantity Generator (SQG) is all about. One thing I note is that the state program in Massachusetts is much more stringent regarding the SQG than at the federal level. At the federal level we talk about 100 kgs. per month - about a half of a drum. Since February, 1988 Massachusetts now regulates nonhousehold generators of any quantity of hazardous wastes. I can't think of many electroplaters that are not at least small quantity generators. Further, electroplating and plating in general is one of the major areas of concern for RCRA mainly because it is what we call a non-stop operation. There is a lot of waste generated and a lot of it is highly toxic waste. They are working with cyanide, heavy metals and solvents. We are talking about an industry in general that is geographically very diffuse and yet the point source is generating what we consider a very toxic waste. This problem of small quantity generators has just been recognized. Most of the new federal rules for small quantity generators of hazardous waste became effective on September 22, 1986.

RCRA is the Resource Conservation and Recovery Act. It started in 1976 and really did not become a program until 1980. It took four years to write and certify what Congress wanted us to do. RCRA is the government's attempt to get industry to deal with its waste stream discharges. Prior to the RCRA regulations, we had inadequate waste identification, inadequate responsibility, inadequate soil standards, little information, no emergency notification for the local community, and no incentives for industry for dealing with its waste appropriately. This led to very undesirable consequences. We can say that 90% of the hazardous waste was handled unsoundly. I went to Lafayette College as an undergraduate and down below was a Crayola factory, not too far off the stream from where I could look out my dorm room. I remember, daily, I knew which crayons they were making that day by the color of that stream water. You can take the Chicopee River out towards Springfield, and it changed color daily, depending upon what lack paint was being made at one of the large chemical companies along the site. You don't see such things today. That does not mean that

contamination is not there. It means that we have improved the management and what we have are thousands of sites.

Question: You said improvement. Does that mean that they are now storing it in drums instead of dumping into the river and the toxics are still sitting there to be dealt with?

Answer: Right. But they have reduced the amount they are generating, because it costs so much money to send it off-site. We monitor from cradle to grave the movement of waste at these same sites.

In brief, we are talking about 1.5 million tons per year of hazardous wastes being generated. Again, primary affected industries would be electroplating. The number of people in the Federal RCRA program is about 75. In the DEQE program, I think we have another 170, so you are talking about 250 for the whole region trying to regulate all these industries.

The objectives are to protect health, protect environment, preserve valuable material resources, and conserve valuable energy resources. For the platers, of course, we are talking about quite a valuable resource. If we can conserve the metal discharges it means we don't have to import platinum, for instance, one of the critical raw materials of which about 90% comes from South Africa. The story is similar in the case of gold; very high proportions come from South Africa. The best way to do it is conservation, reuse and recycling.

The pretreatment program's purposes are to control hazardous waste, eliminate dumping, and encourage resource conservation. Of these three, the hardest is the encouragement of resource conservation. I think part of it is a legacy of our past. We do not think of resource conservation, it is not part of something we learned when we went through school. A throw-away attitude is a legacy of this generation, and remember these industries are run by people of that generation. They do not easily think of recycling.

A very important aspect of the program is state authorization. In New England one of our authorized states is Massachusetts. We still have two that are not on line, Connecticut and Maine, whose programs were not satisfactory, or stringent enough.

Let us take the characteristics of hazardous wastes. They are considered hazardous if ignitable (their flash point below 140 degrees F); corrosive (pH higher than 12.5 or lower than 2); reactive; or EP toxic which means you run water through it and the leachate coming out of it is toxic.

The cradle-to-grave system is based on interacting networks between generators, transporters and disposers. A plant may receive toxic materials which are not wastes. Through the industrial process a waste is generated. Transporters come to the back door, load the drums into their truck, and take it off site. The transporter has a copy of the manifest with 5 or 6 carbons in it and the generator is supposed to receive a copy of it. When we go out to inspect the generator, we expect to see not only the manifest that he gave for the movement of this waste off the facility, we also expect to see the one which came from the disposer. This copy is supposed to be received within ten days. They have to have both of those documents.

One thing I am concerned about when I go out to inspect platers is land disposal. Let me tell you what land disposal is. Let's say they have a pipe that goes out the back of their building and it goes into what looks like a swimming pool. This is illegal as of November 8, 1985, but some companies are still doing this. If you notice anything like that contact us. You see, they are dumping into this swimming pool and what is happening is that it is infiltrating right into the ground and attacking groundwater which is a very precious resource. Now, when I say it is illegal, it is illegal unless it has double liners and in all New England there are only 110 facilities which have that. They are required to have permits, and obviously in Massachusetts it has been a requirement to have permits for a long, long time.

Another thing these 1984 amendments require is a ban on land disposal. Certain solvents, as of 1986, can no longer go into a landfill. What is going to happen to those solvents if a company manifests them. They can't do so because their transporter cannot get anybody to accept them. We are concerned that they are going to end up in the sewer system (POTWs).

Whenever we talk about Sub-Title C we are talking about hazardous waste facilities, where Subtitle D is your local solid waste landfill. Congress is really concerned about Subtitle D, landfill. One

of the reasons is a lot of the small quantity generators over a long period of time have been dumping their materials into the solid waste landfills, municipal landfills, and as we all know, these are turning out to be major problems, especially with groundwater contamination. These are some of the Subtitle D costs. The reason I bring this up is that not allowing such generators to dump these things into the local landfill or the sewer is a reason for them to undertake waste minimization.

In Massachusetts the small quantity generator is any generator of less than 1000 kg of hazardous waste in a calendar month or less than one kg of acutely hazardous waste. All generators must get an EPA identification number. The generator I. D. number is critical since all of the notification, all of the information on it gets into the data base and is used to try to get this industry to do what they have to do. The I.D. number is the first step. Generators are required to make sure that waste containers meet standards, and they must have emergency preparedness and prevention plans, including appropriate training for employees handling the wastes. But I think the most important thing is that the program provides a way of tracking of the waste.

One thing I want to say about the small generator program is that the small generator program really is a state-operated program. At EPA, we also go out to inspect some of these facilities but mainly to see how well the state is doing its program and also to supplement their workforce, because we realize that they have constraints on personnel. We all cooperate. If they know they want to go out to a certain small quantity generator, but they do not have the personnel to do it, they call us up and we go out and do the inspection.

The EPA has available a rather large manual, to help a facility determine if they are generating hazardous waste.

Pretreatment Standards: An Overview

Gerald Potamis, U. S. Environmental Protection Agency

Introduction

The industrial treatment program should protect the method that the POTW (publicly-owned treatment works) has chosen for sludge disposal. We have many pollutants that will go right through the treatment plant without being treated and cause a violation of water quality standards - numerical and narrative. The state of Massachusetts, like many other states, has a narrative standard which says that you cannot discharge pollutants in toxic amounts. Many people paraphrase that and say you can not discharge toxic pollutants and toxic amounts. The key is toxic amounts. Many people say, why are you letting people discharge any toxics, heavy metals, or any of these pollutants that we know cause a problem? The reality is that you do not go in front of the judge and ask for zero discharge, (though that may be the ultimate goal). The law is against pollutants in toxic amounts, consequently dischargers have a right, by law, to discharge certain pollutants. It is how we define "toxic amounts" that keeps Paul, myself, and other regulators in business.

In New England, we do not see a lot of wastewater recycling, perhaps partly because compared to other parts of the country we are very water rich. With the amount of rainfall we get in any one year, and the amount of surface water available to us (unlike the Midwest), you will not see a lot of big land application projects for wastewater.

Pretreatment

The regulations derive from the national pretreatment strategy and are one set of general pretreatment requirements. They are real life regulations, long-winded and written to be legally correct. Every time you write something to be legally correct, without loopholes, it is likely that some statements in there will not make sense. We do have a basic bible, namely the general pretreatment regulations. Within the general pretreatment regulations, we have established three sets of standards: categorical pretreatment standards, prohibitive discharge standards, and local limits. I'll go into the

latter two later because I think that is where we should focus to meet the goal of the source reduction program.

In the pretreatment program we identify certain POTWs throughout Massachusetts that we feel could be impacted by industry. The regulations say that for a facility designed for a flow greater than a million gallons per day that has the potential to be impacted by industrial wastes, the regional divisional director of water pollution control can require to have a pretreatment program. In Massachusetts, (and this statistic is pretty consistent through much of New England and nationwide), about half of our programs for small POTWs are for less than 5 million gallons per day. We have some programs with only 1 or 2 discharges, we have some programs with more. Sometimes these would be industrial waste treatment plants, which were sometimes classified as a public treatment works to facilitate the receipt of federal funding.

We want the POTWs to be a policemen, so to speak. They are authorized like the state agency to regulate industry. But many communities with POTWs do not have the statutory authority to regulate industries to the degree we would like to see. So we looked into the basic enabling legislation that the state gives the communities to regulate. If there are established sewer use ordinances, how is the community now going to take that statutory authority and actually implement it on a day-to-day basis? Does the community have the right to walk in and inspect an industry? Do they have a right to copies of discharge reports? Do they have a right to do anything? Industry is protected by constitutional rights to privacy so you can not assume that communities have a right to inspect. They do not. The rights they have are the rights to protect public health and safety. It is a long drawn-out process to make sure that communities have the legal authority to police industry.

When you have two communities working together, it becomes even worse because you may have one community that has the discharge permit and another community discharging into it. Now you have communities fighting, complicated by the fact that often they are engaged in attracting industries. Since industries can provide jobs and property tax dollars besides being pollution dischargers, there can be serious conflicts here and turf battles stretching from City Hall to the state regulatory agency, the governor's office, and the EPA.

The community develops this program, we give them some money to do it. If we don't give them money, we put it in their permit requirement and we force them to do it through a permit condition. They go and try to develop certain technical information about the industrial discharges. They need to develop an industrial users survey (a list of what industries are discharging in their community). They try to identify what the flow is, what type of products they manufacture, what types of pollutants they are discharging. While this appears to be a straightforward activity, in practice it turns out to be almost impossible to get this kind of information. Therefore, we often approve programs with less than ideal information in them. Here in Boston, the MWRA (Metropolitan Water Resources Authority) has something like 5,000 industries to control. By the time you get specific information on every one of the 5,000, the first company you obtained information on may have changed; so we do the best we can.

Communities like Attleboro and North Attleborough do not have that many industries. However, some of these industries are smaller and some of them have no idea what they are discharging and they do not like it when you say go and spend $3,000 or $4,000 for a priority improvement analysis, which is a one-time snapshot of discharges. The problem is what may be in your discharge today at three o'clock in the afternoon may not be typical of what is there on the following day. Try to ask them to do that for a full week or a month. These firms cannot afford to do it. As is typical of many environmental issues, it is a balancing act. There's no right answer. If you are the Regional Administrator, you get to make some of those calls and get a lot of public input; both pro and can, often vehemently expressed. Hopefully, we try to come down in the middle, or at least on the side of the consumer.

Question: Do the municipalities have the authority?

Answer: Yes they do. They go out and say, someone put something undesirable in the stream, we suspect this is what it is and we need to take a look at it. They do have that authority. The person opening the door at the plant may not let them in. They may have to. We would like to say, we do not need warrants, but the civil liberties people probably will disagree. We have to go back to the judge and get a warrant. To repeat, yes the municipalities have that authority and the POTW has that authority. We have it by virtue of the Clean

Water Act, the communities have it by virtue of state legislation and home rule charter.

The municipalities also have to develop procedures on how they are going to enforce pretreatment standards. The lawyers will say you can not be arbitrary or capricious. We are trying to clean up the environment but we have to do it in a reasonable manner, everybody should know the actors and the rules of the ball game.

Finally, they have to have a proper organization to run a program, adequate resources and funding. For years, water treatment was on the low end of the pay scale and did not attract too many people. In Massachusetts Proposition 2 1/2 limits money available from local sources. It comes out of POTW or taxpayers or the industries in that town. Basically, we like to say that the industry should pay for the operation of the pretreatment program since it serves them. However, there are some regulations that may suggest that they should not. In some communities, industry could not bear the higher burden of running a pretreatment program. Then, the community should have the right to fund the program somehow, and should have a mechanism to get the money. It is the community's business how they do it, so long as it is legal. Our role is to get in and try to make sure that the system works.

Discharge Standards

In addition to the regulations I talked about earlier, I said there were three types of standards: prohibitive discharge standards, categorical standards and local limits. Prohibitive discharge standards are applicable to all industrial POTW users. There is no way to waive those standards even if a community doesn't have a pretreatment program; industries have to observe the standards. The problem though, as you can see, is that all but two of them are narrative. Most of these standards are what any good sewer use will have. You do not want something that will burn or something that will cause explosions to the sewer system, you do not want something that is corrosive, etc.

We have another requirement, of temperature. That temperature requirement pertains to the maximum temperature of the head works of the treatment plant. Generally, that will translate into a temperature for the pipe discharging outside the industry of

around 150 degrees F. That's a number that shows up in all the facilities. In general we don't have quite that elevated a discharge.

Categorical Pretreatment Standards

We initially started off with 34 primary industry groups (e.g. electroplating, metal finishing, etc.), which we regrouped into about 20 odd categories of pre-treatment standards in order to regulate industrial pollution. These standards are technology based. In other words, we looked at a particular industry and sub-categories of the industry in light of what that industry can do, what that industry has been doing or what it is capable of doing, and we then established a standard.

Recently, we went into New Bedford and found an electroplate that was not meeting our standards. We got him on a criminal fine for one million dollars for non-compliance with our electroplating standards. Though there may be many such cases of non-compliance in Attleborough we are probably unlikely to enforce the standards immediately and close down Ma and Pa small shops because of job losses, the bad press, the bad politics, and the minor fines you could levy. An important fact to note about agencies such as ours is that the alleged violation must stand up in a court of law. The EPA lawyer, the Department of Justice and the U. S. Attorney are three sets of lawyers who decide on whether to bring a court case. No one wants to go into court if there is a possibility of losing the case. That does not mean the lawyers are afraid of losing, but their behavior is constrained by the precedents set in the district court at the state level. That is why the lawyers like to pick the cases that have legally provable violations, that can get a lot of money, a lot of sympathy, and set examples.

If I find a violation of one of our pretreatment standards, that is a violation. We do not actually have to prove the detrimental impact to the environment. Violation of the standard itself is enough to go to court. Note, too, that there is a distinction between civil and criminal cases. If we go after someone for a civil fine, the party pays a fine and walks away. In the New Bedford case, we went after that industry for criminal fines. Not only does the dollar amount go up drastically for the criminal fines, but we can also seek to put people in jail. In addition to a criminal fine on the corporation, the judge can make a special instruction indicating that he found the firm

criminally liable, and if the firm did not clean up its act soon he would go back in and find an officer of the firm criminally liable.

In the New Bedford case, the industry knew what the standard was, the standard had been in place for several years, and they were a very large corporation. There was no way they could prove ignorance of the law. Since they had also submitted reports to us that indicated that they knew what they were doing, that part of the case was easy. However, if you talk criminal violation you do scare a lot of people and some of the small producers may be hesitant to talk to you.

Citizens cannot sue us to force us to sue industry. The reason I say that is because there was a Conservation Law Foundation suit against us. In the Boston Harbor case, the judge held that regulatory agencies have the discretion regarding whom they sue. A citizen's group cannot sue the agency to sue a polluter. However, the citizen's group can sue the polluter under the Clean Water Act -- a situation feared by many industries. The ability of citizens to sue an industry for violating our standards comes from the Clean Water Act.

There are quite a number of the categorical industries. In the case of tempered products from iron and steel industry, we issued standards on 1/26/81. The regulation did not become effective until 3/30/81 for legal reasons, and the pretreatment standard for existing source discharges was not a requirement almost three years later. Most of our categoricals have this feature. We come out, we issue a standard and we give industry time to comply. Usually, it takes 2 or 3 years.

The metal-finishing industry was supposed to meet total toxic organic, standards by 2/15/86, and electroplating should be there in the same period. Any metal finisher or electroplater should be well in compliance at the present time.

Local Limits

Finally, we have local limits. This is what in North Attleborough and Attleboro we are going to try to get. They generally will also cover non-categorical industries. These are locally determined and are federally enforceable, once we approve the program. The calculation of a local limit is more easily said than done. Basically, what determines it is how much can an industry

discharge so it would not cause the treatment plant to violate water quality standards. The POTW has to know the limits we are putting on it so it can know what limits to impose on industry. As you may have heard, we are just starting that process. We approved interim standards for the Attleboro POTW program a couple of years ago, before the new standards were out. I am not sure if discharging industries must meet the interim standard, which are not strict enough, or the new standards.

Question: Can a treatment facility establish standards more stringent than those you levy and still call upon you to enforce those standards?

Answer: Yes, but before we undertake to do so, we will have to make sure that their higher standard was developed properly. It is not an easy task. You have to make sure you know who all the discharging industries are, what they are discharging, what the treatment plant capabilities are, and what the receiving stream capabilities are.

We generally know that the industries in Attleboro are going to have an easier standard than if they were discharging directly to the river, but still these industries have a major task. We regulate the treatment plant, which gives allocations to the industries that discharge to it. The whole program should be developed in less than a year, that with no problems. Still, there are a lot of unknowns. We know what the treatment plant is supposed to discharge, but we don't know what kinds of heavy metals we are concerned with and what the true level of removal efficiency is at the treatment plant.

What amount of pollution can that treatment plant remove? Generally, for copper we remove around 80%, for some of the other heavy metals the removal efficiency is only around 30-40%. When you are talking about closing down an industry because of heavy metal discharges, more specific knowledge is needed. Further, you have to look at sludge disposal. If the proposal is to use a landfill, has the application been made? Another standard to look at relates to some of the organics. After you consider in this manner about half a dozen pollutants and heavy metals, you get an idea of what the standard should be. There are 126 priority pollutants that were identified by the EPA many years ago. There are thousands of other pollutants out there that are toxic but are not subject to standards.

When you really start thinking about it, standard setting and implementation is a slow process. We are going after the heavy metals and some of the organics. For this purpose, we use computer models, and DEQE has a very similar computer model but both are somewhat rudimentary. Basically they do a lot of routine calculations very quickly and help in our activities.

The regulatory process is not always as straightforward as the written regulations. Within 82-85 days after we issue a categorical standard, the affected industries are supposed to send us a baseline monitoring report identifying a lot of things about their operations -- about their manufacturing process, what their unit operations are, what their flows are, what their sources of pollution are, and a schedule for coming into compliance. Some of the small plating companies you are going to visit should have baseline monitoring reports that will help you understand their situation. Sometimes, they put such reports together and sometimes they have not even submitted it. If they have not it is a violation. Even such platers have to conform within 90 days of the compliance deadline and say they are or are not in compliance. All those industries in the Attleboro, North Attleborough area should have given us a compliance report or should have given Attleboro a compliance report by now, but they probably have not. Again, there are two reports you can look for, baseline monitoring and report of compliance. A third one is the periodic compliance report -- every six months they are supposed to report to the POTW whether or not they are in compliance with their categorical standard locally established by the community.

I will describe very quickly the baseline monitoring report. When you are going out in the field and when we are discharging and meeting federal standards, you watch out. Whether the standards are met depends where you measure it. In a simple analysis of many industries, you notice a process flow, a sanitary flow and a bunch of other flows, all of which are unregulated flows. If you measure at some points (where many people will try to measure), you are getting the benefit of dilution from sanitary and other unregulated flows. Consequently, depending upon where they say they sample, you have a first indication of whether they understand the process. Our categorical standards are generally met at the end of the wastewater treatment process. If they do measure it at that point, there is a formula they can use, (called the combined waste formula), which is nothing more than a flow weighted average.

We have many communities where homeowners are discharging copper that industries cannot. That is one reason why there is a local limit. The industry says that it has to discharge regularly, the POTW wants to regulate copper. In such cases, one has to find out what residential and miscellaneous contributions are, and allocate reduction responsibilities.

Finally, we have come up with a treatment system we think will work and is also very innovative in recycling.

To provide a little wider perspective let me note that there are 103 plants on our list, for Attleb o, North Attleborough and Taunton. The initial issue for all of them is wastewater discharge. Some of the small plants come and go. When we sent out our notices of meeting with the plaintiffs, the next week we got three of them back (addressee unknown); at the same time we found four new companies that appeared with name changes as new companies. Of that set of 103 companies, 52 did not have the necessary RCRA permits (solid and hazardous waste discharge management). I do not think that it is possible to meet the present water discharge standards without some pretreatment. The big firms are particularly vulnerable, they are probably being dealt with by EPA, by DEQE, by the local POTW. I mentioned a couple of nights ago a study that was done in Providence, which said that if everybody who was discharging in the Providence, POTW met a 3 ppm copper level, the copper level discharged to the POTW would come down by 70%. Again, the smaller plants are acting illegally in Providence too.

How did the Attleboro POTW meet its discharge limits before? It made a political decision that it was easier to spend money than to enforce that the smaller plants pre-treat. The POTW itself takes the heavy metals out, since otherwise the levels would destroy the biological action in in their treatment plant. So the POTW did the pretreatment and the cost of enforcing the pre-treat tilted them in that direction.

State Environmental Policy

Thomas Powers,
Massachusetts, Department of Environmental Quality Engineering

Introduction

I propose today to talk about the Department of Environmental Quality Engineering, a Massachusetts state agency, in terms of what we do, how we fit into other state agencies, and how our work relates to the U. S. Federal Environment Protection Agency (EPA). I shall begin with a general overview of enforcement. I shall tell you how we go about finding a violation in the first place, what the different options are for us to consider when we find a violation and finally, how we handle a violation after we find it.

Probably the most interesting or certainly the newest tool that we have is something called administrative penalties. I shall give you some examples of how we assess these penalties, what documents are involved, and how the penalties work.

I am the Chief Enforcement Counsel at the Massachusetts Department of Environmental Quality Engineering (DEQE). DEQE is the sister agency of the Department of Environmental Management (DEM). DEM essentially does planning and works on solving environmental problems. DEQE does regulations and enforcement, which means running a permit system and implementing requirements.

The more industrialized and more specially concentrated the society gets, the more you have to pay attention to wastes. In Massachusetts we have federal delegation of the Resource Conservation and Resource Recovery Act (RCRA) which means that DEQE is the lead enforcement agency concerning wastes. In the Reagan administration the emphasis is on delegation to the state as much as possible. This strategy gives the state more control as to decisions, and as to setting priorities. While EPA does some of its own enforcement, its major focus is on reviewing the state's actions and plans for enforcement.

DEQE is an agency of about 800 people. It is growing at a phenomenal rate as more and more environmental problems are

identified, people want action on them, and more and more statutes get passed. A recent example is the move to clean up hazardous waste sites, which is an enormously complex and expensive activity. Once you have allowed hazardous waste sites to appear, it is very expensive and difficult to clean them up to some level of safety, particularly given the uncertainty as to exactly what is a safe level.

DEQE also administers air quality, water quality, and wetlands protection in Massachusetts. Basically, I think it is fair to say that people meet the requirements established for environmental protection for two reasons. Either because it is in their economic or other interests to do so or because they are legally required to do so. You can convince people that environmental pollution control is in their economic interest. Source reduction is a very good example -- you can convince people that everybody wins by reusing resources or reducing their waste disposal costs. More likely however, is the case where it is not in your immediate interest. Corporations or companies are set up to make money and they try to invest in things that produce more profits. Under traditional production practices waste control is an expense, and it almost always seems cheaper to just dump the stuff into the environment. If you're a corporate manager with pressures to get more production, unless someone makes you focus on it, you usually are not going to give serious attention to what to do with your wastes.

Noncompliance Penalties

It is particularly important, we think, to assess penalties in cases where there were serious past violations involving people who did not obtain permits. This is a change from the way DEQE used to operate. Until a couple of years ago, we basically said if we find somebody who is dumping pollution onto water without permit, what we ought to do is say, hey, you've got to comply with the state's environmental law. Here is a permit application, file the application, and we will review it and if it is o.k., we will issue the permit and then you will be legal. As long as you do that, we'll let bygones be bygones and not worry about what happened in the past.

Now, we think the environmental laws have been around long enough that it seems fair that any reasonable person ought to know about them. So we are not very moved by the argument "I did not know there was a requirement that you could not discharge into water." If people conclude that all that is going to happen to them is

that they are going to be in the same position as if they complied all along, such a situation would put the companies that always complied with the permit system at an economic disadvantage compared to those who use the "ignorance" argument. We really do not want to put the honest law abiding person, which most corporations certainly are, at a disadvantage. We are talking about a small percentage of people, but it is important that the others understand that something bad happens to the small percentage of violators and that companies that comply are not losing out by doing the right thing. The violators will pay the monetary penalties usually issued by the DEQE. If it is a really serious violation, DEQE will go after somebody as a criminal matter.

The hardest problem to start with is finding the violation. DEQE has a lot of inspectors, although not nearly as many as we would like who basically find violations by doing a record search---looking through documents---and identifying people who have registered for one thing and appear to be emitting or discharging something else, and by following up complaints from citizens or other municipalities. We are incredibly far from having the resources where you can just drive around the countryside looking for violations. A lot of the stuff does not lend itself to driving around looking for violations anyway, so most often it is either somebody in the government or a concerned citizen who calls up and says, "this looks so strange, have you DEQE guys got a record of that, are they doing something illegal?" Then we send somebody out to look at it who will decide whether or not the facility is in compliance.

When we go out to a particular facility and find a violation, we start considering our options, which fall into four major categories:

1. Notice of Noncompliance

2. Administrative or Enforcement Order

3. Referral to the Attorney General's office for court action. This can be either an injunction (a court order requiring somebody to do something or stop doing something), a civil penalty, or in worse cases a criminal penalty and potential jail sentences for somebody who knowingly and maliciously dumped harmful materials.

The notice of noncompliance essentially puts somebody on notice that they should be looking at this problem, and if the problem persists they risk further sanctions. The notice says, we think you damaging the environment. Let us know by a specified date how you propose to come into compliance. The notice, however, is not enforceable the way an order is. If you get a notice of noncompliance and you believe the agency is sort of mixed up about that, and you are really not in violation, you do not have to do anything. But you are on notice and it is probable that DEQE will come back to you later and say, you have still got this problem. You cannot use ignorance as an argument, because the noncompliance notice was sent to you. The notice gives the person a warning, therefore giving them a chance to correct the violation. Ninety percent of the time, or more, that we send somebody a noncompliance notice, they fix the problem and that's the end of the story. But sometimes DEQE must go a step further, and issue an administrative penalty.

Administrative Penalties

An administrative penalty is issued by an agency as contrasted to a penalty assessed by a court. It is not uncommon in the country; at least 35 of the states have administrative penalties in one or more programs. It was enormously controversial in Massachusetts. Industry thought that DEQE would run amuck, slapping penalties indiscriminately. The bill was in the legislature for seven years. It started off with just a tiny chance of getting anywhere and each year it got a little further along. I think it is fair to say that DEQE was not particularly enforcement-oriented until eight years ago and we didn't really push it that hard. There are an awful lot of violations going on out there; the courts are too slow, the Attorney General's Office does not have enough people. If DEQE is to deal with small and moderate size environmental problems, it ought to have the right to assess some money penalties on some violators. These are the reasons for the administrative penalty.

One of the consequences of any complex piece of legislation, particularly a very controversial piece of legislation involving a serious compromise, is that what finally emerges is something nobody would have drafted had they started out and just written it. One of the important points won by industry was that most of the time firms should get a warning before being penalized. Typically when an inspector for DEQE finds a violation, industry says that these

environmental statutes are very complex, it is tough to know when you are in violation. DEQE ought to give the firm some warning, give it a chance to fix it, and if fixed, DEQE ought to go away since its goal is compliance. DEQE agreed, but the environmentalists said, well that might be all right most of the time but there are certainly exceptions when you should not have to issue a warning first. An example of that might be that about three years ago there was a styrene leak in Acton when a tank ruptured. In the middle of the night there were air raid sirens going, there was gas escaping and people were being evacuated. Nobody was seriously injured, but everybody was mad. Upon investigation it appeared as though the company might have put a little more attention into keeping track of the level of this tank. There was never any penalty assessed against them, and the statute at that time provided for a penalty of only $15 to $100 for violations. The situation has since been corrected and the penalty set at $5,000-$10,000 (The maximum administrative penalty DEQE can assess is $25,000).

If everybody had to get one warning before levying the penalty that firm would not have been penalized. The environmentalists insisted there had to be some exceptions. One exception allowed is for an activity that has a significant impact on public health, safety, welfare, and the environment, in which case DEQE can penalize immediately.

The general principle however is that you have to give the firm a notice about a violation first. Also excepted are those activities that are "willful and not the result of an error." Essentially if somebody intended the activity that caused the violation, we can penalize them without a notice of noncompliance first. Another example relates to a pattern of noncompliance. In regard to a couple of hazardous waste facilities, every time DEQE went out, they had fixed the previous problem but then there would be another one. The conclusion reached by DEQE is that they just are not paying much attention, that they do not really care about keeping up with environmental regulations but they know enough to fix it after we go out and tell them. At some point you ought to be able to say, the facility operations ought to take this matter more seriously, and be able to assess them a penalty.

After the legislature has passed statutes (which are very general) the agency such as DEQE implements them, guided by specific regulations it develops. In the case of very controversial

legislation an advisory committee is established. In that format, DEQE met every couple of weeks for about some months or so with industry, environmental, and municipal representations figuring out how these specific regulations would work and what the requirements should be. The administrative penalty regulations apply to all the DEQE programs -- air, water and hazardous waste, and emphasize mid-sized and small-size violations. For major violators, DEQE can still go to the Attorney General's Office and get a court order; if the issue gets very complicated, it is sometimes useful to have a judge overseeing the compliance.

A lot of our time is spent on deciding whether there is a pattern of noncompliance in a facility, weighing many factors. The problem is even more complex in companies like Digital Equipment Corporation, which has 28 facilities in Massachusetts.

How can an inspector keep track of what happened at every one of those 28, in a fairly decentralized system? DEQE uses a variety of criteria developed through years of regulatory experience, that help decide patterns of noncompliance and the size of the administrative penalty.

One of the ways to make compliance more prevalent than noncompliance is to remove the economic benefit of the violation. You do not want to give somebody an incentive to not comply, figuring that if they make $50,000 by the violation and if they get penalized at $25,000 there is not any reason to comply. The primary goal of the administrative penalty is to act as a deterrent. Given the large number of facilities and the small number of regulators in DEQE and EPA, one tries to get enough of an impact, enough press and enough potential sanctions to persuade firms to conclude that it is a good idea to comply. So, the primary goal of DEQE is not to punish or to get this particular firm in compliance but to make sure that everybody else understands that it makes sense to comply and that's very important.

While DEQE is supposed to consider the financial condition of a violator, this is a fairly tough requirement because often the information is not available to DEQE. Basically, we are guided by common sense considerations, how much pe le did to avoid the problem, how quickly they tried to fix it wi n they found it, what steps they were taking to prevent recurrence.

The document for penalty assessment is somewhat like a notice of noncompliance in the sense that it tells the person what he did. The idea is to set forth in a logical format exactly what the requirement is, who the parties are, why the firm is getting the notice. These documents in the case of hazardous waste cases go up to 10 or 12 pages stating that for all these reasons and because of a failure to comply with the notice of noncompliance of willful violation or whatever, DEQE assesses an administrative penalty of $20,000 or $50,000. It ends with a statement of the method of payment, and the format of how to appeal if they want to.

The appeal is 21 days from request and is called a judiciary appeal. The Commissioner of the Department appoints a lawyer to be the hearing officer and that person acts as a judge. The appellant is pretty much always represented by a lawyer and may offer some expert witnesses or consultants. The firm can appeal either the fact of a penalty, say "you have the wrong guy, I did not do it, it was not a violation after all," or the amount of the penalty. It is fairly rare that somebody can come in and persuade us that there was no violation because usually an expert has been out there and they can see this violation. Occasionally, it is the case that there is some ambiguity in a regulation or a requirement so it is not so clear, but most of the time, the fact of the violation is clear. However, the firm can also argue about the amount of the penalty and that means it can bring in any of the criteria for assessing penalty amounts and say that DEQE did not take them into account properly. The potential for this type of argument is very large. We are generally hopeful that we will figure out a way to settle although we try to avoid routinely settling cases for less money than their assessment, because then you are encouraging everybody to appeal.

Once the hearing officer or commissioner issues the final decision, the firm has basically three choices.

1). Pay and forget it.

2). Ignore it and let us go after the firm, in which case DEQE is authorized to seek, through the Attorney General's Office, three times the amount of penalty. It is not likely that we will get that penalty unless the firm is really intentionally avoiding DEQE, but it is enough of a sanction to make people more nervous about ignoring us.

3). The firm can appeal to the court. The court just reviews whether or not DEQE made an error in law or had substantial evidence to support this decision. This is a very tough burden to overcome for the firm since there is almost always enough evidence in the record to support DEQE's decisions. The violator also has to put the amount of the penalty in escrow. The environmentalists were very concerned that people would just appeal and save themselves the use of the money for years, if they didn't have to pay it up front, so you have to put it in an interest-bearing escrow account and if you are a real violator and you lose in court, then the Commonwealth gets the amount of the interest.

The easiest way to think of the penalty is really looking backward. The penalty is for what happens up to the day when you went out and saw them. The other kind of thing that we often do, the administrative order, is really forward looking. It says you must do this, this, and this to correct the violation, and it is often the case that it costs more money to correct the violation. Somebody might have to put in a $200,000 treatment system as well as pay a $20,000 administrative penalty. The press and publicity factor of the administrative penalties are fairly significant, and certainly the cost to the company of having to comply with the order can be very significant.

Other Actions

Finally, if a case is quite serious, DEQE often refers the case to the Attorney General's Office and that means instead of assessing the penalty ourselves, we have the Attorney General go into court and ask the judge to order the person to comply and put them on an enforceable schedule as well as assess them a civil penalty. One of the reasons that one might want to go to court in a fairly big case is when DEQE has not issued a notice of noncompliance, that is, an introductory letter giving a first warning to a particular violator. Even when we do issue a notice of noncompliance, the maximum penalty you can get under the administrative penalty system is $25,000. While this seems like a fairly substantial sum, often people have saved a couple of hundred thousand dollars by their illegal actions, and $25,000 doesn't seem like that much. The Attorney General is not limited by that, but is implementing and enforcing a different statute -- the one that sets up the water pollution and

hazardous waste requirements in the first place. Those statutes allow for the collection of up to $25,000 per day without any earlier warning so that if we think that the right amount of penalties is worth more that $25,000 that would be one reason why we would want to go the court. People take courts a lot more seriously. On the other hand it tends to take longer and depends upon more people and that kind of thing. There are real advantages in the administrative penalty procedure for quick enforcement and quick response.

That is a brief capsule summary of DEQE enforcement, administrative penalties in particular. I might just add that in the administrative penalty statute, the maximum penalty for violations which involve operating without a license or not in compliance with a permit and discharging things directly into the environment is $25,000. Most serious violations are initially assessed at perhaps $10,000 and are adjusted up or down depending on how hard the person tried to prevent the violation, how much they did to fix up any harm they caused because of the violation, etc. All other violations have a maximum of $1,000. Violations of reporting and monitoring requirements and the new right-to-know statute which involves reporting about chemicals that the companies use, bear maximum penalties of $250 per day.

Recycling Regulations

Doug Wallace
Massachusetts Department of Environmental Quality Engineering

Introduction

I would like to make a few comments about the small quantity generator, in particular the differences between Massachusetts and the federal EPA approaches. DEQE regulates down to 20 kg., (roughly 5 gallons), but we have for several month been revising the regulations so that we come in line with the federal definition. We plan to raise the cut-off definition of small quantity generators to the level used by the EPA. However, in addition we would like to see some kind of regulation take place for generators under 100 kgs.

For those generating less than 20 kg per month there is a performance standard which requires them to dispose of their wastes in a way that does not endanger the environment. This requirement is hard to enforce, since it is very easy to hide a small amount of waste and throw it in a municipal landfill.

So, keep in mind that the portions of the RCRA regulations that relate to small quantity generators are in flux and we are continually fine turning them at the state level.[1]

Recycling

I'm going to talk about recycling waste, namely hazardous waste. The state's recycling regulations are developed from EPA's

Since the definition of waste reduction will affect the design, implementation and efficiency of public action, definition of terms is important. Yet the term waste reduction means different things to different people. Tabel 1 (drawn from OTA, 1986) illustrates these problems. We adopt here the definition of waste reduction as in-plant practices that reduce, avoid, or eliminate the generation of hazardous wastes so as to reduce risks to health and environment. It includes the following activities (OTA, 1986, ICF, 1986):

[1] Since February, 1988, Massachusetts has regulated generators of less than 100 kg per month and no acutely hazardous wastes as very small quantity generators (VSQGs).

final regulations. In order for a state to be authorized to enforce the RCRA law, we have to be at least as strict as these regulations. EPA has to consider a wide range of states when they issue regulations; some states might not want to regulate a waste stream while others may think it appropriate. In Massachusetts we are more strict in several areas. For example, since 1973 we have regulated waste oil as a hazardous waste while EPA does not. There is quite a lot of opposition to that idea at the Federal level. It remains to be seen what will happen in the long run if you have waste oil that is toxic, and has a lot of impacts.

Secondly, we have a licensing system in Massachusetts for transporters, in which we regulate some recycling and some hazardous wastes that EPA has exempted. EPA has said that certain materials like industrial alcohol and materials that are recycled on-site are not called solid waste and by implication not hazardous waster. Massachusetts has decided to regulate these materials along with activities such as lead-acid battery reclamation, because we are more strict and we are concerned about the fact that these materials might be mishandled and released into the environment.

Our approach is really an attempt to balance two goals. One is environmental protection and human health and safety and the other is the encouragement of recycling. Recycling is a viable option, increasingly so over time, because disposal costs are spiraling upwards all the time. The number of landfills available for hazardous wastes is diminishing all the time. Many are being closed, more are being mismanaged while others are just filling up. As a consequence, the economic pressure is pushing business and industries toward more effective management of their wastes. There is another distinction that I would like to make too. EPA has done a sort of four tier system in terms of managing hazardous wastes. The first is source reduction, whose objective is to reduce the production of wastes in the first place. That is the most preferable alternative.

Second comes recycling. Since a firm has already generated waste it may either reuse it or clean some portions out of the waste so that it serves another or similar purpose somewhere down the line, in effect lessening the prospect for waste release into the environment.

A third approach would be destruction of hazardous wastes and a final one is to put such wastes in landfills somewhere and hope

that the day of reckoning for that is not too near. Since there are not any landfills in this state, the pressures on generators for disposing these wastes is increasing all the time.

Depending upon the particular material that the industry generates our regulations encourage recycling by lifting certain restrictions. For example, there are restrictions in terms of the storage time limit on hazardous waste by the generator. A small quantity generator can store wastes for 180 days before this waste can be disposed of. A large quantity generator can store for three months. In Massachusetts, anyone generating more than a kilogram per month of an acutely hazardous waste such as cyanide is going to fall in the category of a large quantity generator. They will treated just like somebody who generates a thousand kilograms a month or five drums of other hazardous waste - they are going to fall under a more strict regulatory regime than other small quantity generators.

In addition, certain kinds of recyclable materials are exempt from the transporter fee that Massachusetts imposes on the transportation of hazardous waste. We have a transporter fee which returns some money to the state to help finance our transporter licensing, regulation, and recycling program. Then finally, some of these regulated recyclables are exempt from requirements that the materials be transported by a licensed hauler. These are all measures to encourage recycling and to ease the economic burden of environmental protection.

Again, there are different levels of hazards posed by different kinds of hazardous wastes. I want to point out that in order to avoid causing concern about hazardous wastes, we have used the term regulated recyclable material to refer to hazardous waste that is being recycled. There are classes A, B, and C, regulated with different levels of stringency. The class A recyclables are EPA-exempted wastes that are not solid waste but industrial wastes, e.g. non-leaking lead-acid batteries, or materials that are recycled on-site in a totally enclosed system. For example, in Massachusetts some wastes are not sent for burning, but are cleaned by centrifugation or some other process. All these are Class A recyclables. The big break here is that Class A recyclables do not need to be transported from the site of generation to the recycler via a licensed transporter. They can be sent by common carriers who abide by regulations from the Department of Transportation and the Department of Public Utilities

as applicable. Class A recyclables are also exempt from the requirement to use hazardous waste manifest.

Class B recyclables include waste fuels which might be any kind of listed or characteristic wastes from which you can get some energy by burning. The restriction here is you can't burn something in an incinerator just for the purpose of disposal. It has to have some BTU value, so that you can have energy recovery. In addition, waste oils contaminated with heavy metals or solvents, and precious metal wastes are involved here. The applications that are required for a Class B permit are more stringent and require more detail on the part of the applicant. Not too many breaks are given. Class B recyclables have to be moved in most cases by a licensed transporter, have to use a manifest, involve more paper work, and more expense.

The class of recyclables that is regulated almost like hazardous wastes is Class C. These include any that do not fall into Class A or B. They are reusable but have to be shipped away for reclaiming or cleaning up. I cannot think of too many examples because we do not have very many applicants for a Class C permit. The major break for permittees is the ability to store for a longer period, more than the 180 days that is the norm for other hazardous wastes.

Precious metal wastes are subject to a Class B (4) permit. The generators of precious metal wastes do not need a permit unless they want a break on the storage time limits. If they would like to store for a longer period then they will send in a fairly simple application telling us how they are going to store these wastes and there are all kinds of inspection requirements they will have to support.

For precious metal wastes, the transporter must be either a fully licensed hazardous waste transporter or have a special Class B IV transporter permit that limits the transporter to precious metal wastes. They have to provide information to DEQE on their equipment, driver training, and safety precautions.

The facilities to which these precious metals are sent must have a RCRA license or a B (4) recycling permit. Obtaining a RCRA license is quite an involved process, very expensive and time consuming. The B (4) is very strict in terms of having personnel training for dealing with hazardous wastes and contingency plans. Massachusetts permits can only be issued to in-state recyclers. We

cannot get involved in permitting somebody in Maryland or Oklahoma. If some generator in-state wants to ship their precious metal waste to an out-of-state recycler, that out-of-state recycler has to be a TSD facility, licensed under RCRA, or they must have a clear definition from their own states that would be similar to our B (4).

I have mentioned the advantages for having the B (4) permit. In general, recycling of precious metals is cheaper than shipping to a regular facility.

Wastewater Treatment Technology

Bill Hebard
Waste Management Consultant

Introduction

Today's electroplating shop managers must consider limiting the discharge of pollutants from their shops to an absolute minimum to enable the normal operations to remain cost effective. Any raw material resulting as waste now becomes a double loss, and unless it can be reclaimed for reuse it becomes a major economic loss. It is more desirable to prevent raw materials from becoming waste than to recover them from the waste stream. That is what makes source reduction and waste minimization so attractive.

Proper management is a major prerequisite to effective waste treatment. With this in mind, let us look at the options available for disposal of treated wastewater. This will be the determining factor for deciding how clean you must make the wastewater, how much of the pollutants must be removed, and what will be the costs associated with this treatment.

Discharge Options

The alternative adopted by most industries has been to discharge treated wastewater effluent directly to a watercourse. Limits for water quality are established by a federally (EPA) issued discharge permit. The second alternative is an indirect discharge to a watercourse via a publicly owned treatment works (POTW). The third option is to reuse the treated effluent and have a "zero discharge."

Wastewater treatment by direct dischargers must meet permit requirements to remove toxic wastes such as cyanides, metals, and organic solvents, and to eliminate certain nuisance conditions such as color and odor. Recently, these limits became more stringent than the limits established for safe drinking water. Indirect discharges to a POTW require treatment sufficient to remove toxic pollutants that may damage sewer system workers, that may interfere with and inhibit biological treatment at the POTW, and that may pass through the POTW, thus violating the POTW permit for direct discharge.

Other liabilities include toxic contamination of POTWs' organic sludges which would make incineration impossible without toxic air pollution, composted sludge unmarketable, and result in classifying the sludge as a hazardous waste. Obtaining a zero discharge requires substantial wastewater treatment so as to recycle 100% of the process water into rinse waters in such a way as to not adversely affect quality control in electroplating operations.

Finally, one must keep in mind that most raw materials used in electroplating operations are toxic, corrosive, reactive and/or flammable. They pose liability concerns anytime they have potential for health and environmental damage.

Process management

Despite the degree of treatment desired there are various preliminary steps required without which no degree of treatment can be achieved with any consistency.

We must focus attention on the sources of pollutants and keep incompatible streams segregated. Pollutants such as solvents should be kept out of the wastewater stream as they cause problems with treatment and are difficult and costly to remove once mixed with other pollutants in the waste stream.

Source reduction and substitution of raw materials with those that are less hazardous or more amenable to treatment have a major impact, reducing the concentration of pollutants requiring removal.

Water conservation reduces the volume of wastewater requiring treatment and reduces the size of the treatment facility and its cost. Water conservation also allows the use of batch treatment as an alternative to a continuous flow system. All too often pollutants are discharged after one pass through a continuous flow system. The operator does not get a second chance to capture pollutants. However, in batch treatment processes, waste is held in the treatment process for an extended time and the batch is tested and discharged only after it meets permit specifications.

Other preliminary steps are to recover precious metals such as gold and silver from drag out solutions, and to take all possible steps to prevent precious metals from entering the rinse water waste stream.

Acid wastes should be segregated from alkaline wastes to prevent heat generation and fuming.

Flow equalization should be utilized in continuous flow systems to provide a steady state in the volume and concentration of the waste stream. This allows treatment to be optimized without variations.

Cyanide wastes must be treated before being mixed with acidic wastes. If cyanide is not destroyed in pretreatment, toxic cyanogen chloride gas is formed. To prevent such hazards, cyanide distraction usually takes place as a two-stage process.

Before any treatment is actually accomplished you should dilute strong concentrations (greater than 30 oz per gallon) with weaker rinse waters. Adding treatment chemicals to strong cyanide produces violent eruptions, splattering, and tremendous heat generation which can rupture process tanks and cause injury to operating personnel.

Treatment

Once safety has been addressed and satisfied, actual treatment can begin. The process most commonly used is called alkaline chlorination reduction of cyanide. The intent is to reduce cyanide to cyanate in the first stage and convert cyanate to carbon dioxide and nitrogen gases in the second stage. Although most cyanide waste streams are alkaline, the pH is elevated to an optimum value of 11.0 (within a range of 10.5 to 11.5) to prevent a release of gas when the oxidizer is added. Lime or caustic soda are used to raise the pH. Caustic soda is used since it mixes well and produces less sludge residue. Lime is used if chelants are present. Contents in the treatment vessel (first stage reactor tank) are continuously mixed. Control instrumentation is used to measure pH and operate caustic or lime feed pumps.

Once pH is optimized, chlorine is added to oxidize the cyanide. Usually sodium hypochlorite is used since it is safer than chlorine gas. Chlorine liquid is pumped into the treatment vessel until a reduction demand is met as indicated by an oxidation-reduction potentiometer (ORP). This potentiometer indicates that a chemical reaction is complete and it shuts down the chlorine feed pump. Set

points in millivolts are often used as a control range. The high set point is usually 670 millivolts. When the demand is met, a bridge is formed and the controller drops to a low set point, usually 120 millivolts. Instrumentation usually comes equipped with a chart recorder. Looking at the chart, ORP is indicated by a wavy line, the higher the waves, the higher the cyanide concentration.

First stage treatment takes approximately 25 to 45 minutes for complete reduction from cyanide to cyanate.

In the second stage, sulfuric acid is added to lower the pH value to an optimum of 9.0 (a range of 8.5 to 9.5). This provides a safety margin in the event some cyanide goes through. The ORP controller starts feeding chlorine solution until the demand is met at which time cyanate is converted to gases. Although nitrogen and carbon dioxide are harmless, adequate ventilation must be provided to insure against asphyxiation from oxygen deficiency. Second stage reactions take about 45 to 90 minutes detention time. Although the reaction is complete, the rule of thumb is to maintain a chlorine residual. The logic here is that if there is a residual of the oxidizer (chlorine), there can be no reducing agent (cyanide) remaining. Contrary to theory, however, any time cyanide (which is a chelator) is tied to a metal, say iron (ferri-cyanide complex) the cyanide will not be destroyed by alkaline chlorination.

If the second stage reaction is incomplete, ammonia will be formed. Ammonia is a chelating agent which will interfere with the next segment of treatment which removes dissolved metals. Lime, on the other hand, can be used to break complexes and prevent ammonia formation.

Where processes using chromium are present, a pretreatment step must be performed to reduce hexavalent chromium. Highly concentrated chromic acid solutions should be added to rinse water slowly for dilution. Pretreatment of hexavalent chromium is called chromium reduction. This process reduces hexavalent chromium to trivalent chromium. Without this step chromium cannot be precipitated or taken from a soluble state and converted to a particle form by means of hydroxide precipitation. Only by using sulfide precipitation can this step be eliminated.

Reduction is achieved by lowering the pH to 2.5 (a range of between 2.0 and 3.0) usually with sulfuric acid. Adjustment of pH is

"instrumented" with controller and chart recorders. As the optimum pH is reached, a reducing agent such as sodium metabisulfite, sodium sulfite, sodium bisulfite, or hydrosulfite is added. Economics and the goal of lowered sludge production dictates the selection of a reducing agent. Again, the contents of the reaction vessel are constantly mixed during treatment. The ORP controller operates the reducing agent feed pump, and chrome reduction usually occurs at about 250 millivolts. The detention time requirement is usually between 15 to 30 minutes. Chromium is now in the trivalent stage, amenable to further treatment.

Let's take a moment to review what we accomplished thus far. Solvents, oils, and precious metals have been captured at the source of these waste streams. Acidic rinse flows have been segregated from alkaline and cyanide bearing flows. The flows have been equalized to create steady state conditions after a strong water conservation effort has been accomplished. Cyanide has been destroyed and hexavalent chromium has been reduced in separate pretreatment systems.

We blend these major waste streams together for the purpose of metals removal. The common metals are usually iron, tin, lead, zinc and copper. However nickel, aluminum, cobalt, arsenic, antimony and traces of gold and silver may be present.

Metals are precipitated in the so-called final neutralization tank. Precipitation is the converting of a dissolved (soluble) metal into a solid (particulate) metal form. Solubility is dependent upon pH. Each metal will return to solid form at its lowest solubility levels, corresponding to pH value. Since different metals have different solubility levels, different metals precipitate at different pH values. Therefore, a range of pH values has been established to remove a majority of all metals in the waste stream. This range is between 8.0 and 9.0. This conversion occurs as quickly as sugar dissolving in water when a chemical is added to achieve the optimum pH.

The contents of the neutralization tank are constantly mixed so complete reactions occur. As chemicals are introduced. pH controllers raise the pH using caustic soda or lower the pH using sulfuric acid, dependent upon the incoming pH values. The detention time in the mixing tank is usually between 3 and 7 minutes. As the pH changes, the dissolved metals are converted to particulate

microfloc. These particles require a long time to settle out of the carrier water. This is because in cold water, they are about equal to the density of water, and in warm water they are slightly denser (heavier than) water. To remove these metal hydroxides or microfloc, they must be able to settle. They must gain in size and weight.

The next step does just that. The waste stream flows to the flocculation tank where mixing is slowed considerably to prevent re-solubilizing and shearing. The detention time is approximately 30 to 45 minutes. A coagulator polyelectrolyte (polymer) is added which has a charge enabling microfloc to attach to each other and grow dense. Microfloc "grows" in size from salt-like particles to those about the size of a finger nail. They look like snow flakes.

The polymerized solution flows to a tube or plate-settling device called a clarifier. Here the detention time is increased to about 1 to 3 hours. Solids which now are heavier than water settle moderately and uniformly in the clarifier, and form a dense blanket of hydroxide solids (sludge). As the incoming flow passes through this blanket, finer particles unaffected by flocculation become entrapped. As the flow moves upward through the inclined tubes or plates, it becomes evenly distributed so as to prevent or minimize any carry over or drag out of lighter solids. The resultant discharge is relatively clean. However, surges in flow conditions and floating solids may result in flows containing some residue.

As the settled solids accumulate, they must be removed or they would eventually fill the clarifier and become part of the discharge. While maintaining a blanket for entrapment, excess sludge is removed (wastes) to a conical-shaped gravity sludge concentrator tank. Some of the sludge in the clarifier is returned continuously back to the flocculator to artificially add solids to create floc when metal concentrations in the waste stream are below 300 milligrams per liter.

Sludge in the concentrator separates by gravity, leaving water (supernatant) on top and thick sludge at the bottom. The supernatant is withdrawn slowly back to the clarifier inlet while the sludge is pumped to dewatering operations.

Clarifier effluent then undergoes pressure filtration to remove any remaining solids. These solids are physically trapped in sand

media and prove beneficial in breaking down organic "biodegradables" in soap cleaners. When the filters become clogged, they are back-washed with filtered effluent similar to filters used for swimming pools. The filtrate, which contains the solids, is sent to the flocculator at which time the clarifier recycle flow is reduced.

At this point, the filtered effluent is relatively clean, but it still contains some dissolved metals that found their way through the system, and other dissolved salts such as sodium and chlorides. The combination of these pollutants could prove to be toxic if discharged to the environment or could cause problems in the electroplating process if reuse was attempted.

Ion exchange uses cationic and anionic resins in columns to attract these dissolved substances. Ions are exchanged with those having opposite charges and are absorbed onto the resin column. De-ionized effluent water can now be discharged or recycled for reuse. As the columns become saturated, they must be backwashed with either dilute sulfuric acid or caustic soda. This produces a concentrated brine solution of either acidic metal or alkaline salts. Metals in the brine can be evaporated to a semi-solid state and shipped to a refinery. Alkaline salt solutions can be neutralized and discharged to the sewer.

Sludges from the concentrator are dewatered, usually by means of plate and frame filter presses. This filtrate is usually returned to the flocculator. The dried hydroxide sludge is usually manifested to a hazardous waste landfill. Some industries now export their sludges to Canada where a proprietary process stabilizes, sludge in a special matrix which relieves industry of further liability. Precious metals, solvents and oils kept out of the treatment processes previously outlined must also be properly handled.

Carbon filters usually remove organic brighteners and other contaminants prior to ion exchange. This preliminary step prevents fouling of the resins. The solution containing such metals as gold, silver, platinum and rhodium is pumped through resin columns containing selective ion resins. The column collects precious metal cations. The solution then passes through an anionic resin column and is returned to its source. As the resins become saturated, as indicated by a conductivity meter, they require backwashing or regeneration. The cationic column is regenerated with dilute sulfuric acid while the anionic column is regenerated with dilute caustic soda.

The resultant brine with precious metals is evaporated and sent to the refinery.

Electrowinning uses an insoluble carbon anode to plate out precious metals. Evaporation uses distillation to concentrate precious metals while producing distilled water for reuse. Ultrafiltration uses pressure to force water through micron-size pores in membranes leaving behind a precious metal brine, evaporated and sent to the refinery.

Oily waste is removed by skimming, coalescing, emulsion breaking, flotation and ultrafiltration. Selection of the proper system depends upon the volume and type of oil. Oil, although considered hazardous waste, can be used as a fuel. Solvents are usually re-distilled over and over again for use, while only the bottom sludges are manifested as hazardous waste.

Complexed metals are the single most difficult treatment problem. They remain in solution despite hydroxide precipitation. Several methods exist to break down the chelating agents that complex metals. Sulfide precipitation has proved successful, however it's costly. Likewise, sodium borohydride at pH values of 6.0 (range 5.0 to 7.0) can be used although it too is costly. Chemical reduction using ferrous sulfate, ferric chloride and calcium chloride dissociates the complexed equilibrium, releasing free metal ions which are now amenable to hydroxide precipitation. Sludge production can be expected to increase.

This concludes the discussion on wastewater treatment technology. Everyone should strive to minimize the amount of waste generated because reduction alone is the single most effective method of waste treatment. It's cheap, it requires little technology, and there is no liability involved.

Electroplating Technology

Oscar Nietzel
Industry Consultant

Let me begin with a few definitions. I have for you a six-page summary of definitions taken from a book by Ken Kerri (Treatment of Wastwater from Electroplating, Metal Finishing and Metal Waste Streams. California State University). These definitions are useful for both metal-finishing and waste treatment operations.

An important one is the CAS number. When you start going to these plants, the only way you are going to understand what chemicals are involved is to get a copy of the Material Safety Data Sheets (MSDS), an item required by law that identifies the materials used. In the MSDS you will find the CAS number, the identification number assigned by the Chemical Abstract Service of the American Chemical Society. Platers are prone to using all sorts of slang and sometimes you don't know what chemicals they are referring to. For instance, if someone says "lime" they might mean calcium hydroxide, calcium carbonate, or calcium oxide. Calcium carbonate is limestone, and calcium oxide is "burnt lime", calcium carbonate that has been roasted in a furnace. When mixed with sweat, it will burn on contact with the skin. Another kind of confusion about definition concerns the concentration of a material. If you buy "12 molar" hydrochloric acid that means there are 12 moles in a liter. It is not the same as 10 molar HCl.

Another important term is grab sample. I don't know how many plants I go into where they go around with something they call the grab sample. As far as I'm concerned the only thing it is good for is for taking temperatures, because if you wait two minutes it's going to change. If you are going to understand what is going on in the waste stream, you are going to have to understand the time/volume interdependency of the flow. It someone tells you they took a grab sample, ask them what the temperature was. It is not going to tell you much more than that. What you need is a composite sample -- a collection of individual samples obtained at regular intervals, usually every one or two hours during a 24-hour time span. Each individual sample is combined with the others in proportion to the rate of flow when the sample was collected. The resulting mixture forms a representative sample and is analyzed to determine the average

conditions d[illegible] the sampling period. For example, you take a sample in a [illegible]n the morning, you measure the flow -- it is, say, 10 gallons per minute. Then when you take a sample in the afternoon it is 100 gallons per minute. Your composite sample must contain 10 times the volume of the afternoon sample in relation to the morning sample. That way the two samples can be combined and a composite sample representative of conditions over time is generated.

Also, make sure the sample is representative of the condition you looking for: for example, if you are measuring a tank, don't draw your sample down stream from a pipe coming out of the tank, when another adjoining pipe may alter the characteristics.

Another item I want to draw your attention to is complexed metals: these have a tendency to remain in solution rather than to form precipitates and settle out. They have reacted with or are tied up with chemical complexing agents such as ammonia or citrates, tartrates, quadrol and EDTA. They pose special problems because they are not easy to remove from wastewaters; thus, they should be segregated.

To remember the definition of hazardous waste, ask if the waste possesses any of the characteristics of waste that make it hazardous: does it exhibit FCTR -- hazardous FACTORS? FCTR stands for Flammability, Corrosivity, Toxicity, and Reactivity. If a chemical has any of these characteristics, it is hazardous by law.

Does anyone have any idea what POTW is? People have to dump two ways: they either dump to a stream, in which case they have a National Pollutant Discharge Elimination System (NPDES) permit, or they dump to a publicly owned treatment works (POTW), a sewage treatment plant. Some of these POTWs, trying to treat sewage, are getting oils, or material that suds all over the place, and they don't know what's coming down the pipe to them. It's a sad state of affairs.

The industry has a problem of housekeeping or should I say the lack of it. There are a few plants that are truly spotless but in most places the operations are careless, there are spills on the floor, problems associated with scrubbers, organics, nitric and sulfuric acid fumes in the air, etc. Spills and uncontrolled chemicals create waste stream problems that could easily be avoided, but most people don't even think about it. If you walk into a plant and see a lot of slop on

the floor, you know they have a waste treatment problem. It goes without saying.

Sources of Wastewater

Wastewaters at industrial facilities come from several different sources such as cleaning, preparation, production and rinsing processes, as well as the washing of equipment and production facilities. These processes produce various types of industrial wastes such as toxic organic solvents used as degreasing and cleansing agents; highly acidic or basic solutions used for cleaning, plating and pH adjustment; cyanide from plating processes; and toxic metals from the basic plating solutions.

The metal waste streams from electroplating, metal finishing and printed circuit board manufacturing originate mainly from six types of electroplating operations.

1. ELECTROPLATING is the production of a thin surface coating of one metal upon another by electrodeposition. In electroplating, metal ions supplied by the dissolution of metal from anodes or other pieces, are reduced on the workpieces (cathodes) while in either acid, alkaline, or neutral solutions. The electroplating baths contain metal salts, alkalies, and other bath control compounds in addition to plating metals such as copper, nickel, silver or lead. Many plating solutions contain metallic, metalloorganic, and organic additives to induce grain refining, leveling of the plating surface, and deposit brightening.

2. ELECTROLESS PLATING is the chemical deposition of a metal coating on a workpiece by immersion in an appropriate plating solution. Copper and nickel electroless plating for printed circuit boards are the most common operations. In electroless nickel plating the source of nickel is a salt, and a reducer is used to reduce the nickel to its base state. A complexing agent is used to hold the metal ion in solution. Immersion plating produces a metal deposit by chemical displacement; however, it is not an autocatalytic process but is promoted by one of the products of the reaction. Immersion plating baths are usually formulations of metal salts, alkalies and complexing agents (typically cyanide or ammonia).

3. ANODIZING is an electrochemical process which converts the metal surface to a coating of an insoluble oxide. The formation of the

oxide occurs when the parts are made anodic in dilute sulfuric or chromic acid solutions. The oxide layer begins formation at the extreme outer surface, and as the reaction proceeds, the oxide grows into the metal. Chromic acid anodic coatings are more protective than sulfuric acid coatings and are used if a complete rinsing of the part cannot be achieved. Anodizing wastewater typically contains metals and either chromic or sulfuric acid. When dyeing of anodized coatings occurs, the wastewaters will contain chromium or other metals from the dye. Other potential pollutants include nickel acetate (used to seal anodic coatings) or other complexes and metals from dyes and sealers.

4. COATINGS include chromating, phosphating, metal coloring and passivating. Pollutants associated with these processes enter the waste stream through rinsing and batch dumping of process baths. The process baths usually contain metal salts, acids, bases, and dissolved basis materials. In chromating, a portion of the base metal is converted to a component of the protective film formed by the coating solutions containing hexavalent chromium and active organic or inorganic compounds. Phosphate coatings are formed by the immersion of steel, iron, or zinc plated steel in a dilute solution of phosphoric acid plus other reagents to condition the surfaces for cold forming operations, prolong the life of organic coatings, provide good paint bonding and improve corrosion resistance. Metal coloring involves the chemical method of converting the metal surface into an oxide or similar metallic compound to produce a decorative finish. A variety of solutions utilizing many metals may contribute to the waste stream. Passivating is the process of forming a protective film on metals by immersion in an acid solution, usually nitric acid or nitric acid with sodium dichromate.

5. ETCHING AND CHEMICAL MILLING are processes used to produce specific design configurations or surface appearances on parts by controlled dissolution with chemical reagents or etchants. Chemical etching is the same process as chemical milling except the rates and depths of metal removal are usually much greater in chemical milling. The major waste stream constituents are the dissolved basis material and etching solutions.

6. PRINTED CIRCUIT BOARD MANUFACTURING involves the formation of a circuit pattern of conductive metal (usually copper) on nonconductive board materials such as plastic or glass. There are five basic steps involved in the manufacturing of printed circuit

boards: cleaning and surface preparation, catalyst and electroless plating, pattern printing and masking, electroplating, and etching.

Additionally, water may be used for subsidiary purposes such as rinsing away spills, air scrubbing, equipment washing, and dumping spent process solutions.

Plating can also be done by putting pieces in barrels, hanging them on a rack, or running them through as a continuous strip. This is called reel to reel plating.

Why do we plate? To improve corrosion resistance, to increase wear resistance, to control electrical properties, and to reduce friction wear. And of course, to confer on a surface the desirable appearance and quality of a precious metal, say gold, without having to have a piece be gold through and through.

Electroplating is based on Faraday's law (1890's). I haven't met anybody in metal finishing that has changed it yet. The law specifies the time-current product required to produce a definite weight of plated deposit. Many people don't understand how to make baths correctly or they create inefficient baths.

We also need to be familiar with the concept of current density. This is the total current divided by the total cathode area, generally expressed as amps per square foot. The cathode is the piece being plated. This definition gives the average current density. Depending on the shape of the piece being plated, current density will vary and therefore, the thickness of the deposit will vary. Sometimes you may run at only half an amp per square foot, other times at a thousand amps per square foot (this is spot plating). The ionic content of the bath is adjusted for current density.

There are some common chemicals that are run into in plating systems. When you plate gold and silver, typically you are going to be working with sodium cyanide and potassium cyanide. When you destroy cyanide, you break it down into carbon dioxide and nitrogen.

Common Chemicals

In order to plate correctly, there should be no foreign material between the base metals and the deposit. Oils and greases are typically eliminated through the use of solvents. Degreasers only

degrease; they do not remove dirt, only oil and grease. These are commonly halogenated hydrocarbons. When spilled into the ground, they keep going down because they are denser than water. They will go down until they find an impervious layer. Thus they are significant contributors to groundwater pollution. Solvents can generally be replaced with emulsifiers, which make the oil float off the surface. Skimming of the oil then generally won't be sufficient to clean the wastewater sufficiently for discharge, and a membrane filtration system may be necessary.

Another approach is to avoid getting the piece full of oils and greases in the first place. Water with a surfactant is actually better than oil for cutting. Lighter oils that are easier to remove can be used. Or the bulk of the oil can be spinned off. People have accepted solvent cleaning as part of the manufacturing process; it is not always needed.

Dirt can be removed by soaking in an alkaline solution. Electrolytic cleaning works because the electrical current forms hydrogen or oxygen bubbles on the surface of the piece -- this action lifts off dirt depending on the polarity. Ultrasonic cleaning works because the sound waves actually compress the water, making it more dense, and then release pressure, again and again, creating a mechanical scrubbing action. If the water is gas-loaded, the gas will be compressed and the cleaning is minimal. Thus you must heat the water to at least 60-70 degrees centigrade to drive out dissolved gases efficiently. If you put your hand in the ultrasonic bath, the compressive action will damage your capillaries: be careful.

The last kind of foreign material that needs to be removed is surface film -- oxides. Acid activation is normally required as a final surface preparation. Some platers activate with a highly concentrated solution of cyanide. This is unnecessary and dangerous, and more expensive if you are doing your job and destroying the cyanide.

There are other chemicals that go into plating, but they are not of the significance of what we have discussed. There are chemicals called "brighteners", which I call "grain refiners." They affect the grain size of the metal, which changes the appearance of the piece, making it brighter. Grain refiners may be proteins, sometimes they are complex carbohydrates -- sugars, or molasses. In the old days, urine was a source of proteins.

Let me go through some basic guidelines for cleaning certain items. The proper cleaning for stainless steel is to go through an alkaline system, then an aqua regia dip -- a bath of both nitric and sulfuric acid. Stainless steel is chrome bearing, but you cannot plate onto a chrome system because it does not have a surface to which the plated metal can adhere. To allow for adhesion, you need to lay down a thin layer of nickel, which will deposit in spicular form -- tiny spikes of nickel metal will stand out and provide a surface to which the plated metal can adhere. Only a very thin layer needs to be deposited -- three to five millionths of an inch thick. This is called a strike. The particular bath that is used is called a "Woods" nickel strike, named after the chemist that developed it.

A strike bath has several purposes besides providing for a thin deposit of some metal on the piece. It is also where the acids, solvents, and cleaners that get dragged out of cleaning baths should end up. The strike bath gets full of these things, and it should be dumped frequently. It sounds wasteful to dump the bath frequently, but the strike bath has a low metal value if you're making it up properly, and if you dump it frequently you will never have to dump your main bath.

I have put together some charts describing the basic cleaning steps for steel and copper, which might be plated with zinc, nickel, tin, copper, cadmium, or silver. A good rule of thumb is to precede a bath with a common ion rinse. The Woods nickel bath has chloride in it, and you usually use hydrochloric acid on the steel before that, so there's no problem. But the tin baths tend to be sulfate based, and so you have to use a sulfuric acid rinse before. Another thing to watch is temperature. A bright tin happens to be a room temperature bath, you have to chill it for it to work right. But electroless nickel baths are 190 degrees Farenheit. In order to avoid thermal shock you have to give the piece a hot water rinse beforehand.

General Cleaning Guide

I also have some tables that show some parameters and materials used for plating different metals, and three more flowcharts -- one that shows the counter current rinsing process that has saved many platers so much water. The sequential rinse process on the bottom, you see, has water draining out of each rinse tank to treatment. You have the flow in and out of each tank. With counter-

current rinsing, the water flows from the farthest tank to the middle and then the first tank, and only then does it drain to wastewater treatment. It actually works, and substantially reduces water use. The next two charts describe wastewater treatment. You have to reduce hexavalent chromium to trivalent chromium for removal by precipitation, recover your precious metals, remove metals from the waste stream by precipitation to a sludge, destroy your cyanides, and separate your toxic organics and oily waste.

Another thing to notice is how the company deals with rejected product. Do they have a large "strip and replate" operation? When a piece is imperfect, do they stop everything and find out what's wrong? When you have to strip and replate, you are using three volumes of water and chemicals for the same piece: the original plating that went wrong, the stripping, and the replating.

There's gold in that waste stream. Don't forget that everything pouring out of that wastewater pipe is paid for, and that includes the water. Everything that goes out usually has to be bought again because of inefficient use. Good management is important. I wish you success.

Tables and glossary reprinted with permission from: Treatment of Wastewater from Electroplating, Metal Finishing and Metal Waste Streams. Ken Kerri, Office of Water Programs, California State University

Printed Circuit Board Manufacturing.

DEFINITIONS OF WORDS

ACID
(1) A substance that tends to lose a proton. (2) A substance that dissolves in water with the formation of hydrogen ions. (3) A substance containing hydrogen which may be replaced by metals to form salts.

ACUTE HEALTH EFFECTS
Health effects which are evident immediately or shortly after and as a result of an exposure to a hazardous substance. (Definition from California General Industry Safety Orders Section 5194.)

ANION (AN-EYE-en)
A negatively charged ion in an electrolyte solution, attracted to the anode under the influence of à difference in electrical potential. Chloride ion (CI-) is an anion.

ANODE (an-O-d)
The positive pole or electrode of an electrolytic system, such as a battery. The anode attracts negatively charged particles or ion (anions).

AQUEOUS (A-kwee-us)
Something made up of, similar to, or containing water; watery.

BASE
(1) A substance which takes up or accepts protons. (2) A substance which dissociates (separates) in aqueous solution to yield hydroxyl ions (OH-). (3) A substance containing hydroxyl ions which reacts with an acid to form a salt or which may react with metals to form precipitates.

BASIS METAL
A metal used to make workpieces and that receives the electroplate and the treatments in preparation for plating.

BATCH PROCESS
A treatment process in which a tank or reactor is filled, the water is treated, and the tank is emptied. The tank may then be filled and the process repeated.

BENCH SCALE ANALYSIS
A method of studying different ways of treating wastewater and solids on a small scale in a laboratory.

CAPTIVE SHOPS
Those electroplating and metal finishing facilities which in a calendar year own more than 50 percent (on an area basis) of the materials undergoing metal finishing. (Definition from "Guidance Manual for Electroplating and Metal Finishing Pretreatment Standards." Effluent Guidelines Division and Permits Division, U.S. EPA, Washington, D.C. February 1984). Also see JOB SHOPS.

CAS NUMBER (pronounce as separate letters)
The unique identification number assigned by the Chemical Abstracts Service (American Chemical Society) to specific chemical substances. (Definition from California Labor Code, Division 5, Chapter 2.5)

CATHODE (KA-thow-d)
The negative pole or electrode of an electrolytic cell or system. The cathode attracts positively charged particles or ions (cations).

CATION (CAT-EYE-en)
A positively charged ion in an electrolyte solution, attracted to the cathode under the influence of a difference in electrical potential. Sodium ion (Na+) is a cation.

CAVITATION (CAV-uh-TAY-shun)
The formation and collapse of a gas pocket or bubble on the blade of an impeller or the gate of a valve. The collapse of this gas pocket or bubble drives water into the impeller or gate with a terrific force that can cause pitting on the impeller or gate surface. Cavitation is accompanied by loud noises that sound like someone is pounding on the impeller or gate with a hammer.

CHROME PLATE
Chrome plate is one of the most common surface coatings for auto bumpers and cutting tools. Also see CHROMIUM.

CHROMIUM
A hard, brittle, metallic element often used in metal alloys and as a corrosion resistant surface coating for metal parts. Chromium is an especially toxic metal, with hexavalent chromium being appreciably more toxic than trivalent chromium. Inadequate or improper

handling and disposal of chromium may create serious environmental hazards. Also see CHROME PLATE, HEXAVALENT CHROMIUM and TRIVALENT CHROMIUM.

CHRONIC HEALTH EFFECTS
Health effects which develop over a long period of time after, and as a result of, a single or repeated exposure to a hazardous substance. (Definition from California General Industry Safety Orders, Section 5194).

COMMON METALS
Alumium, cadmium, chromium, copper, iron, nickel, tin, zinc or any combination of these elements are considered common metals.

COMPLEXED METALS
Metals with a tendency to remain in solution rather than form precipitates and settle out. These metals have reacted with or are tied up with chemical complexing agents such as ammonia or citrates, tartrates, quadrol and EDTA.

COMPOSITE (come-PAH-zet)
(PROPORTIONAL) SAMPLES
A composite sample is a collection of individual samples obtained at regular intervals, usually every one or two hours during a 24-hour time span. Each individual sample is combined with the others in proportion to the rate of flow when the sample was collected. The resulting mixture (composite sample) forms a representative sample and is analyzed to determine the average conditions during the sampling period.

CONTINUOUS PROCESS
A treatment process in which waste is treated continuously in a tank or reactor. The water being treated continuously flows into the tank at one end, is treated as it flows through the tank, and flows out the opposite end as treated water.

COUNTERCURRENT RINSING
A rinsing procedure in which water flows from tank to tank in a direction that is opposite to movement of parts being rinsed from tank to tank.

CYANIDE

The cyanide ion (CN-) consists of carbon (C) and nitrogen (N). Cyanide is commonly found in metal plating wastewaters because most metal cyanides are soluble and plating occurs readily from cyanide solutions. The cyanide ion is extremely toxic and must be removed from metal wastes before discharge to the environment. Treatment of wastes containing cyanide under acidic conditions may produce extremely toxic gases which must never come in contact with people or animals.

DPD METHOD
A method of measuring the chlorine residual in water. The residual may be determined by either titrating or comparing a developed color with standards. DPD stands for N, N-diethy-p-phenylene-diamine.

ELECTROLYTE (ee-LECK-tro-LIGHT)
A substance which dissociates (separates) into two or more ions when it is dissolved in water.

ELECTROWINNING
A reverse electroplating process which uses a carbon electrode (insoluble anode). An advantage of this process is that no sludge is produced.

ELEMENT
A substance which cannot be separated into its constituent parts and still retain its chemical identity. For example, sodium (Na) is an element.

EMPLOYEE EXPOSURE RECORD
A record containing any of the following finds of information concerning operator exposure to toxic substances or harmful physical agents:
1. Environmental (workplace) monitoring or measuring, including personal, area, grab, wipe, or other form of sampling, as well as related collection and analytical methodologies, calculations, and other background data relevant to interpretation of the results obtained;
2. Biological monitoring results which directly assess the absorption of a substance or agent by body systems (such as the level of chemical in the blood, urine, breath, hair or fingernails) but not including results which assess the biological effect of a substance or agent;

3. Material safety data sheets; or
4. In the absence of the above, any other record which reveals the identity (such as chemical, common, or trade name) of a toxic substance or harmful physical agent.
(Definition from California General Industry Safety Orders, Section 3204).

EMPLOYEE MEDICAL RECORD
A record concerning the health status of an employee which is made or maintained by a physician, nurse, or other health care personnel or technician.

(A) Employee medical record includes the following:
1. Medical and employment questionnaire or histories (including job description and occupational exposures);
2. The results of medical examinations (pre-employment, pre-assignment, periodic, or episodic) and laboratory tests (including X-ray examinations and all biological monitoring);
3. Medical opinions, diagnoses, progress notes, and recommendations;
4. Descriptions of treatments and prescriptions; and
5. Employee medical complaints.

(B) Employee medical record does not include the following:
1. Physical specimens (e.g., blood or urine samples) which are routinely discarded as a part of normal medical practice and are not required to be maintained by other legal requirements;
2. Records concerning health insurance claims if maintained separately from the employer's medical program and its records, and not accessible to the employer by employee name or other direct personal identifier (such as social security number or payroll number); or
3. Records concerning voluntary employee assistance programs (alcohol, drug abuse, or personal counseling programs) if maintained separately from the employer's medical program and its records.

(Definition from California General Industry Safety Orders, Section 3204).

EXPOSE or EXPOSURE
Any situation arising from work operation where an employee may ingest, inhale, absorb through the skin or eyes, or otherwise come into contact with a hazardous substance; provided that such contact shall not be deemed to constitute exposure if the hazardous

substance present is in a physical state, volume, or concentration for which it has been determined that there is no valid and substantial evidence that any adverse effect, acute or chronic, on human health may occur from such contact. (Definition from California General Industry Safety Orders, Section 5194).

GRAB SAMPLE
A single sample collected at a particular time and place which represents the composition of the wastestream only at that time and place.

HARMFUL PHYSICAL AGENT
or TOXIC SUBSTANCE
Any chemical substance, biological agent (bacteria, virus or fungus), or physical stress (noise, heat, cold vibration, repetitive motion, ionizing radiation, hypo-or hyperbaric pressure) which

(A) Is regulated by any California or Federal law or rule due to a hazard to health;
(B) Is listed in the latest printed edition of the National Institute for Occupation Safety and Health (NIOSH) Registry of Toxic Effects of Chemical Substances (RTECS);
(C) Has yielded positive evidence of an acute or chronic health hazard in human, animal, or other biological testing conducted by, or known to, the employer; or
(D) Is described by a material safety data sheet available to the employer which indicates that the material may pose a hazard to human health.

(Definition from California General Industry Safety Orders, Section 3204).

HAZARDOUS WASTE
(Abbreviated EPA definition for identification by testing)

A waste that possesses any one of the following four characteristics:

1. Ignitability, which identifies wastes that pose a fire hazard during routine management. Fires not only present immediate dangers of heat and smoke, but also can spread harmful particles over wide areas. A liquid that has a flash point of less than 140º F (60ºC).
2. Corrosivity, which identifies wastes requiring special containers because of their ability to corrode standard materials, or requiring segregation from the wastes because of their ability

to dissolve toxic contaminants. An aqueous solution with a pH less than or equal to 2 or a pH greater than or equal to 12.5.

3. Reactivity (or explosiveness), which identifies wastes that, during routine management, tend to react spontaneously, to react vigorously with air or water, to be unstable to shock or heat, to generate toxic gases or to explode. A cyanide or sulfide bearing waste which, when exposed to a pH of between 2 and 12.5, can generate toxic gases, vapors or fumes in a quantity sufficient to present a danger to public health, safety, or welfare, or to the environment.
4. Toxicity, which identifies wastes that, when improperly managed, may release toxicants in sufficient quantities to pose a substantial present or potential hazard to human health or the environment.

NOTE: The actual definition is a detailed three-page document.

HAZARDOUS WASTE
(RCRA definition)
A waste, or combination of wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may:

1. Cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or
2. Pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of or otherwise managed.

HYDROXIDE PRECIPITATION
A method of removing common metals from waste streams by the precipitation process. The pH of the metal waste is increased to an optimum level for hydroxide metal precipitates to form for the wastes being treated. The metal precipitates are settled out of the waste stream in clarifiers and are removed from the bottom of the clarifiers as metal sludges.

HYGROSCOPIC (HI-grow-SKOP-ick)
Absorbing or attracting moisture from the air.

IMPURITY
A hazardous substance which is unintentionally present with another substance or mixture. (Definition from California Labor Code, Division 5, Chapter 2.5)

INHIBITION
The introduction of pollutants into publicly owned treatment works (POTW) which could INTERFERE with the operation of the wastewater treatment processes. Also see INTERFERENCE.

INTEGRATED PLANT
A captive electroplating and metal finishing facility which, prior to treatment, combines electroplating waste streams with significant process waste streams not covered by the electroplating category. (Definition from EPA's "Electroplating Guidance Manual")

INTERFERENCE
The introduction of pollutants into publicly owned treatment works (POTW) which could INTERFERE with the operation of the wastewater treatment processes. Also see INHIBITION.

IPCBM (pronounced as separate letters)
Independent Printed Circuit Board Manufacturers.

JOB SHOPS
Those electroplating and metal finishing facilities which in a calendar year do not own more than 50 percent (on an area basis) of the materials undergoing metal finishing. (Definition from EPA's "Electroplating Guidance Manual"). Also see CAPTIVE SHOPS.

MATERIAL SAFETY DATA SHEEET
(MSDS)
A document which provides pertinent information and a profile of a particular hazardous substance or mixture. An MSDS is normally developed by the manufacturer or formulator of the hazardous substance or mixture. The MSDS is required to be made available to employers and operators whenever there is the likelihood of the hazardous substance or mixture being introduced into a workplace.

METAL
An element yielding positively charged ions in aqueous solutions of its salts.

MIXTURE
Any solution or intimate admixture of two or more substances, at least one of which is present as a hazardous substance, which do not react chemically with each other. (Definition from California Labor Code, Division 5, Chapter 2.5)

"MOTHER" CIRCUIT BOARD
The base circuit board or the main circuit board.

MSDS
A document which supplies information about a particular hazardous substance or mixture. See MATERIAL SAFETY DATA SHEET (Definition from California General Industry Safety Orders, Section 5194.)

REDUCTION (re-DUCK-shun)
Reduction is the addition of hydrogen, removal of oxygen, or the addition of electrons to an element or compound. Under anaerobic conditions (no dissolved oxygen present), sulfur compounds are reduced to odor-producing hydrogen sulfide (H_2S) and other compounds. In the treatment of metal finishing wastewaters, hexavalent chromium (Cr^{+6}) is reduced to the trivalent form (Cr^{+3}). The opposite of OXIDATION.

REPRESENTATIVE SAMPLE
A portion of material or waste stream that is as nearly identical in content and consistency as possible to that in the larger body of material or waste stream being sampled.

SALT
A compound which upon dissociation yields cations (positively charged) of a metal, and anions (negatively charged) of an acid radical.

SEGREGATE
To keep separate or prevent mixing (of two or more waste streams). Wastes from various in-plant sources are easier to treat before they become mixed together.

SPECIFIC GRAVITY
Weight of a particle, substance or chemical solution in relation to the weight of water. Water has a specific gravity of 1.000 at 4ºC (39ºF)

TOXIC (TOX-ick)
A substance which is poisonous to an organism. Toxic substances may be classified in terms of their physiological action, such as irritants, asphyxiants, systemic poisons, and anaesthetics and narcotics. Irritants are corrosive substances which attack the

mucous membrane surfaces of the body. Asphyxiants interfere with the oxidation processes in the body. Systemic poisons are hazardous substances which injure or destroy internal organs of the body. The anaesthetics and narcotics are hazardous substances which depress the central nervous system and lead to unconsciousness.

TOXIC ORGANICS

Organic compounds which can be classified according to the following categories:

CATEGORY	EXAMPLES
1. Base/Neutral Extractibles	Benzidine, Hexachloroethane, Naphthalene, Fluorine
2. Acid Extractibles	P-Chloro-M-Cresol, 2-Chlorophenol, 4-Nitrophenol, Pentachlorophenol
3. Volatile Organics	Benzene, Carbon Tetrachloride, Chloroform, Toluene, Vinyl Chloride
4. Pesticides	Aldrin, Chlordane, Dieldrin, Endrin, Toxaphene

TOXIC SUBSTANCE
or HARMFUL PHYSICAL AGENT

Any chemical substance, biological agent (bacteria, virus or fungus), or physical stress (noise, heat, cold, vibration, repetitive motion, ionizing and non-ionizing radiation, hypo-or hyperbaric pressure) which:

(A) Is regulated by any California or Federal law or rule due to a hazard to health.
(B) Is listed in the latest printed edition of the National Institute for Occupation Safety and Health (NIOSH) Registry of Toxic Effects of Chemical Substances (RTECS);
(C) Has yielded positive evidence of an acute or chronic health hazard in human, animal, or other biological testing conducted by, or known to, the exployer; or
(D) Is described by a material safety data sheet available to the employer which indicates that the material may pose a hazard to human health.

(Definition from California General Industry Safety Orders, Section 3204)

TOXICITY (tox-IS-it-tee)
The relative degree of being poisonous or toxic. A condition which may exist in wastes and will inhibit or destroy the growth or function of certain organisms.

TRIVALENT CHROMIUM
Trivalent chromium (Cr^{+3}) is the reduced state of hexavalent chromium (Cr^{+6}). Trivalent chromium is significantly less toxic than hexavalent chromium and can be removed from metal wastestreams by hydroxide precipitation.

WATER HAMMER
The sound like someone hammering on a pipe that occurs when a valve is opened or closed very rapidly. When a valve position is changed quickly, the water pressure in a pipe will increase and decrease back and forth very quickly. This rise and fall in pressures can do serious damage to the system.

NON-INTEGRATED PLANT
A captive electroplating and metal finishing facility which has significant wastewater discharges only from operations addressed by the electroplating category. (Definition from EPA's "Electroplating Guidance Manual") Also see CAPTIVE SHOPS, JOB SHOPS and INTEGRATED PLANT.

OXIDATION (ox-uh-DAY-shun)
Oxidation is the addition of oxygen, removal of hydrogen, or the removal of electrons from an element or compound. In the environment, organic matter is oxidized to more stable substances. The opposite of REDUCTION.

OXIDATION-REDUCTION POTENTIAL (ORP)
The electrical potential required to transfer electrons from one compound or element (the oxidant) to another compound or element (the reductant); used as a qualitative measure of the state of oxidation in wastewater treatment systems.

OXIDIZING AGENT
Any substance, such as oxygen (O_2) or chlorine (Cl_2) that will readily add (take on) electrons. The opposite is a REDUCING AGENT.

PASS THROUGH

The passage of untreated pollutants through a publicly owned trreatment works (POTW) which could violate applicable water quality standards or National Pollutant Discharge Elimination System (NPDES) effluent limitations.

pH (pronounced as separate letters)

pH is an expression of the intensity of the basic or acid condition of a liquid. Mathematically, pH is the logarithm (base 10) of the reciprocal of the hydrogen ion activity.

$$pH = \text{Log} \frac{1}{(H+)}$$

The pH may range from 0 to 14 where 0 is most acid, 14 most basic, and 7 neutral.

PILOT SCALE STUDY
A method of studying different ways of treating wastewater and solids or to obtain design criteria on a small scale in the field.

POLYELECTROLYTE (POLY-ee-LECK-tro-lite)
A high-molecular-weight (relatively heavy) substance having points of positive or negative electrical charges that is formed by either natural or manmade processes. Natural polyelectrolytes may be of biological origin or derived from starch products and cellulose derivatives. Man-made polyelectrolytes consist of simple substances that have been made into complex, high-molecular-weight substances. Used with other chemical coagulants to aid in binding small suspended particles to larger chemical flocs for their removal from water. Often called a POLYMER.

POLYMER
A chemical formed by the union of many monomers (a molecule of low molecular weight). Polymers are used with other chemical coagulants to aid in binding small suspended particles to larger chemical flocs for their removal from water. All polyelectrolytes are polymers, but not all polymers are polyelectrolytes.

POTTING COMPOUNDS
Sealing and holding compounds used in electrode probes.

PRECIOUS METALS
Metals that are very valuable, such as gold or silver.

PRECIPITATE
(1) An insoluble, finely divided substance which is a product of a chemical reaction within a liquid. (2) The separation from solution of an insoluble substance.

RCRA
Public Law (PL) 94-580. The Resource Conservation and Recovery Act (10/21/78).

REDOX (ree-DOCKS)
Reduction-oxidation reactions in which the oxidation state of at least one reactant is raised while that of another is lowered.

REDUCING AGENT
Any substance, such as base metal (iron) or the sulfide ion (S^{2-}), that will readily donate (give up) electrons. The opposite is an OXIDIZING AGENT.

Source Reduction and Resource Recovery

Robert S. Capaccio, P.E.
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Source reduction and resource recovery technology has gained increased importance in the daily operation of a printed circuit board manufacturing facility. The driving force behind implementation of this technology was once strictly economic; however, recent amendments to federal regulations have added legal incentives for implementation. This paper will discuss typical source reduction and resource recovery techniques that will reduce the cost of constructing and operating the wastewater treatment system and comply with hazardous waste mamagement requirements as defined by the federal Resource Conservation and Recovery Act (RCRA).

Source reduction techniques have many benefits which impact on the daily operational costs associated with the manufacture of the printed circuit boaed. To maximize these benefits, however, it is necessary to coordinate your facility's wastewater treatment and wet processing needs into one plan. Your plan must incorporate source reduction techniques that will maintain both high product yields and quality, as well as comply with environmental regulations.

Benefits which result from source reduction include reduced water and sewer use charges, decreased wet process chemical consumption, and minimized hazardous waste sludge production. These can be significant cost savings, but only if production is not impaired. Implementation of source reduction is also a relatively low capital cost investment which can simplify end-of-pipe waste treatment.

The RCRA has given added importance to the above economic considerations. In November 1984, amendments to RCRA were signed into law by President Reagan, which contained items specifically pertinent to the topic of this paper; including the following:

1.) Manifest -- Hazardous waste shipment manifests after September 1, 1985 must contain a Certification Statement signed by the

Generator that the volume and/or quantity and toxicity of the hazardous waste has been reduced to the maximum degree economically practicable. The method used to manage the waste must minimize the risk to the greatest extent practicable.

2.) Generator Reports -- Biennial reports are required which will indicate the efforts that have been taken to reduce the hazardous waste volume and the reduction that was actually achieved by those methods.

3.) Permits -- The Generator, as a condition for an on-site treatment permit, must certify at least annually the same information shown above as Item No. 2 after September 1, 1985.

4.) Study -- The amendments also require that the Environmental Protection Agency submit a report to Congress on the feasibility and desirability of establishing hazardous waste minimization regulations for the industry. This report is due by October 1, 1986.

These amendments, therefore, back the economic incentive to implement source reduction techniques at your facility by giving legal weight to these requirements.

The first step toward implementing your plan is to quantify all sources of wastewater within the facility. Production yield and quality control data should also be compiled to serve as a benchmark for future comparisons as reduction techniques are implemented. Various sources of wastewater within the printed circuit manufacturing industry include:

- Artwork Processing
- Scrubbing of Wet Surfaces
- Etching of Board Surfaces
- Developing and Stripping of Resist
- Inner Multilayer Surface Treatment
- Multilayer Hole Cleaning
- Wet Deburring and Cleaning
- Electroless Copper Deposition
- Pattern Plating of Copper and Tin/Lead
- Stripping of Tin/Lead from Fingers
- Nickel and Gold Finger Plating
- Solder Reflowing
- Rack Stripping

- Fume Scrubber Wastewater

The quantity of wastewater contributed and the characteristics of that wastewater from each of these sources should be determined prior to any source reduction program being instituted. The major sources of waste chemicals and wastewater production should be critically evaluated for either reclaim or reduction potential.

Hazardous waste reduction methods which can be cited to adhere to RCRA requirements as well as afford cost-benefits include:

- Process Modification and Optimization
- Waste Segregation
- Reuse, Recycle, and Recovery System Implementation
- On-site Treatment and Destruction of Hazardous Waste Materials
- On-site Treatment of Hazardous Waste for Off-site Disposal.

Drag out reduction techniques can be utilized to minimize the quantity of chemical that is discharged from the facility. While these techniques have been previously cited, it is still obvious when one tours various facilities that they have not been widely implemented.

Not only will these techniques have a significant impact on reducing wastewater treatment operating costs, but they can be utilized to document methods taken to reduce the generation of hazardous waste by the facility. When we consider that dragout typically can be reduced by 50% or greater, depending on the withdrawal time of a vertical piece from the bath, implementation becomes imperative.

The simplest form of dragout reduction, other than reducing carry-over into the running rinse, would be incorporation of a still rinse or dragout tank. If the process bath prior to this dragout tank is heated, this solution can be utilized as make-up for the process bath with proper bath purification. However, should the process bath be unheated, then another means of handling the dragout solution will be required.

Implementing batch treatment of the dragout can show a reduction in overall sludge generation due to the efficiency of the batch treatment method over a continuous flow treatment system. However, if the quantity of dragout to be handled becomes

significant, this becomes impractical due to the factor of labor that has to be involved in a batch treatment alternative. Cost-benefit studies would indicate this, as well as the feasibility of instituting automated reclaim measures.

Following implementation of dragout tanks in the facility, an array of resource recovery technoques are available, the choice of which depends on the waste characteristics, quantities generated and cost-benefit analysis in today's market. Technical societies such as The Institute for Interconnection and Packaging Electronic Circuits, and educational societies such as the American Electroplaters and Surface Finishers Society, as well as trade publications such as Printed Circuit Fabrication, will give your staff an important familiarity with the recovery techniques available.

A cost-benefit analysis should be performed with a laboratory pilot test, it necessary, to provide needed data and input, prior to selection of a recovery technique. While ion exchange, evaporative recovery, carbon adsorption and membrane systems have found limited utilization within the printed circuit board manufacturing facility, electrolytic metal recovery of copper and lead has made major inroads.

Electrolytic recovery once was possible solely on baths which contained a high metallic ion concentration. However, with the advent of newer methods to overcome the cathode polarization problems of the dilute solution, recovery is becoming more widely utilized for the common metals, such as copper and lead. Various manufacturers of electrolytic recovery units are utilizing increased cathode area, agitation, or temperature to minimize polarization problems. Since electrolytic recovery utilizes technology familiar to electroplaters, it has a basic appeal to the industry.

Studies performed by our company indicate that, for certain facilities, electrolytic recovery has significantly reduced the unit cost of compliance for copper and lead. Operation and maintenance (O&M) costs that were considered to arrive at the unit cost of compliance included chemicals, electric power, labor and hazardous waste disposal, as well as parts and supplies and labor for maintenance and water charges, permits required, O&M service contracts, and environmental impairment liability insurance premiums.

The degree of success this recovery technology has at your facility depends on the solutions on which it is employed and their chemical characteristics, quantities of dragout, hours of production, final effluent limits requiring attainment, efficiency of the unit, and quantity of metal and sludge reduction obtained. Prior to selection of a recovery system, chemical substitutions should be reviewed for potential use as they will impact on your recovery system.

Chemical substitution of chelated/complexed compounds should be a priority at your facility. Sodium persulfate versus ammonium persulfate for mild etching processes or techniques such as peroxide-sulfuric etching should be investigated. Plasma desmear and etchback has potential to replace sulfuric acid desmearing which replaced chromic acid desmearing - all in descending order of environmental compatibility.

A flag should go up in your mind when a chemical vendor attempts to sell you chemicals containing common complexing or chelating agents if another substitute is available which performs the process at an equal optimum level, but impacts at a reduced level on waste treatment. The minimization of sludge generated from a non-chelated chemical should be considered when comparing costs of raw chemical for processing. Wastewater treatment chemical substitutes for ferrous sulfate to reduce the quantity of hazardous waste production from the chelate/complex side of the wastewater treatment facility should also be reviewed as the cost benefits are significant.

Basic rinsewater flow reduction techniques must be utilized on chelated waste streams or on streams which have a potential for recycle or reclaim of metallic contaminants. The lower the water flow the more cost-effective will be the implementation of reclaim technologies such as evaporative recovery, electrodialysis, or electrolytic recovery.

Significant reductions of up to 60% to 90% are possible per rinse station by adding two tanks versus one tank and further reductions are possible utilizing dragout tanks. By implementing rinse flow reduction techniques, existing facilities can typically save anywhere from 10% to 50% of the water consumed and wastewater generated.

Management techniques can also be employed to reduce the generation of hazardous waste materials for certification under RCRA. There should be clear hazardous waste management policies defined for your facility with responsibilities delineated to control the generation of hazardous waste from each process department.

Hazardous waste that is generated should be stored and shipped properly, including the September, 1985 requirement of waste management reduction certification. By requiring each process department that generates a particular hazardous waste to complete the hazardous waste manifest at the supervisory level, both responsibility and authority to reduce the quantity of waste generated will rest with the proper person.

Certain companies have allocated hazardous waste disposal costs to the responsible department for the waste generation, giving further economic impetus to that supervisor to implement controls. Management should ensure that the purchasing department has a clear understanding of the impact that process chemicals have on waste treatment costs, and that the purchasing department ensures that procurement procedures are implemented which require environmental approval.

There are certain disadvantages of source reduction that must be analyzed to overcome them. Process area floor space is a valuable commodity and inplant source reduction techniques will consume some of that floor space. However, mechanical, if needed, or remote recovery systems can be implemented. Typically, dragout tanks require additional work steps to be implemented by operating personnel, which also give the opportunity for the personnel to miss those work steps to keep up with production demands.

The addition of pumps, electrolytic cells, electrodialysis cells, ion exchange columns, etc, also increases maintenance costs that must be associated with the processing department. Further reclaim of dragout, especially in the method that utilizes dragout as a make-up water to the processing bath, requires increased attention to quality control and contaminant level control within the process bath.

Firms are also investigating, due to the RCRA's impact, recycling portions of their wastewater back into the process for less critical water rinsing needs. Factors that impact on the recycling decision

are: the discharge location of the facility; quantity of dragout that needs to be handled; the chemical costs for both process and treatment; hazardous waste concerns, including environmental impairment liability insurance concerns; and process-quality control impacts. A step-by-step procedure of implementing recycle is recommended to verify quality control and product yields against the benchmark previously taken before recycling further water.

In summary, resource recovery and source reduction techniques have both economic and legal reasons for being implemented at your printed circuit board manufacturing facility. Implementation of these techniques should be a high priority in the coming fiscal year, and certifying to implementation of that program on September's hazardous waste hauling manifest will be required.

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SOUTHEAST SOURCE REDUCTION PROJECT TRAINING SESSIONS

February 2, 1987 -- Introduction to the Southeast Source Reduction Project

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February 17 -- Background of Environmental Law.

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February 18 -- Waste Management Policy

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February 24 -- Waste Management Technology and Source Reduction

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February 25 -- Field Trip to Electroplating shop

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